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Group Dynamics in Extreme Earth Environments: Analogs for Space Missions (Past and Present Expeditions Analysis)

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GROUP DYNAMICS IN EXTREME EARTH ENVIRONMENTS: ANALOGS FOR SPACE MISSIONS (PAST AND PRESENT EXPEDITIONS ANALYSIS)

by

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ABSTRACT

Introduction: Crew performance in space has become an increasing focus of many space faring nations due to the recent shift in focus of colonizing the Moon and then preparing to travel to Mars and beyond. This recent shift in focus to more long-duration missions has moved researchers in the direction of analyzing crew performance aspects associated with crew dynamic development on such long missions. More recently researchers have been analyzing past expeditions carried out on Earth, as these expeditions kept records of crew performance, which have been compared and analyzed to those reported on space missions. **Purpose:** This study investigates a comparison of the recorded errors across time from a well-known past expedition (the Lewis and Clark Expedition) to those recorded by space mission simulation studies, as they provide insight into critical human elements that may be associated with exploration into isolated and confined (or semi-confined) extreme (ICE) environments here on Earth and their extrapolation for future space crews. The study further investigates various aspects of crew psychosocial group functioning through an analysis of group environment, stress, and coping data. Such investigation includes a detailed analysis of pre-mission communication and awareness strategies for positive group functioning and development (Study 1); management of competition and besting among crew members (Study 2); overall crew performance (Study 3); and a comparison of mission mistakes made to habitat problems that arose intra-mission (Study 4). **Methods:** A six person heterogeneous American crew conducted a Mars simulation mission at the Mars Society's Mars Desert Research Station in Utah, USA in 2006. Participants were administered pre-mission assessments of personality, stress and coping, and personal motivation and orientation. Personal mission mistakes and Habitat problems were reported daily by each crewmember to the crew psychologist. Mid- and end-mission assessments were administered to measure cognitive functioning; group functioning/identity; perceived stress and coping; and personal motivation and orientation. **Results and Conclusions:** Data collected and obtained by both assessment and journaling methods were both consistent and indicative of positive personalities desirable of expedition crews. Journals kept by the crew psychologist indicated that crewmembers all felt that the pre-mission awareness of group dynamic development tendencies of past expedition crews was integral in maintaining crew cohesiveness throughout the mission. Crewmembers felt that raising the level of awareness, both pre- and intra-mission, served as a positive factor in the overall positive group dynamic development of the crew. Crewmembers all displayed low levels of competition while still reporting high motivation and satisfaction for group dynamic development and the mission objectives that were completed. The overall analysis indicated effective performance and positive coping with regards to the heavy workload and environmental stressors the crew experienced. A relationship also existed between the psychology assessment data obtained, overall crew performance, and habitat problems that arose.

CHAPTER I

INTRODUCTION

Long Duration Space Flight Research

Individual psychosocial functioning and group dynamic development has recently become an international focus with recent plans by NASA to build a settlement on the Moon, using it as a test-bed for the exploration of Mars and beyond (NASA Vision for Space Exploration, 2004; Suedfeld, 2005). Bishop et al. (2006a) Researchers have noted that this area of recent interest received very little attention during the early years of NASA's manned space program (Bishop, Sundaresan, Pacros, Annes, & Patricio, 2006a; Kanas et al., 2001), but received more attention in the early Russian space program (Gushin, Efimov, Kolinitchenko, & Davies, 1996; Suedfeld, 2005). With the development of space stations (e.g. Salyut, Skylab, Mir, and the International Space Station), space mission durations have increased from a few weeks in duration to six months or longer. Along with this increase in mission duration, crews have become more mixed (multinational and heterogeneous) in terms of gender, cultural background, and professional training (Sandal, Leon, & Palinkas, 2006). While long duration space flight presents very difficult technology challenges, Sandal et al. (2006) indicate that medical and psychological challenges may become a limiting factor for prolonged human space expeditions, especially a three to four-year sojourn to Mars. Therefore, future long-duration missions (6 months and longer) could not only challenge our physical and psychological adaptability, but could also require increased crew autonomy, reliance on automation, and new protocols for communication with mission control for both information sharing and support.

Extreme Environments: On Earth And In Space

An extreme environment can best be identified as "any environment to which humans are not naturally suited, and which demands complex adaptation" (Sandal et al., 2006, p. 281). It has also been suggested that an extreme environment must consider that people may react differently to the same environment, so the limiting factor defining 'extreme' would be the individual's response to the environment rather than the environment itself (Sandal et al., 2006; Suedfeld, 1991). Houston and Cosley (2004) state, "to climb a mountain is to enter a world where one's own insignificance and vulnerability are painfully obvious" (p. 30). While this provides further support of Sandals suggestion that entering 'extreme environments' such as high alpine environments is incredible risky, it is a challenge for the mountaineer to not only learn a variety of climbing skills and techniques, but to learn about the mountain environment itself. Many stressors are present in such extreme environments, especially isolated and confined extreme (ICE) environments such as space and space analog environments (Allner & Rygalov, 2008; Harrison, Clearwater, & McKay, 1989; Palinkas, 2009; Sandal et al., 2006; Suedfeld, 2005).

On Earth there are not many situations and/or places that are as dangerous as space. Probably the most comparable experience to space travel (with regards to risk) would be climbing Mt. Everest, where the risk of death is close to that associated with risk calculations for space travel. With regards to space, the environment is much less forgiving than it is in some of the most 'extreme' locations here on Earth. On Earth we have grown accustomed over time to be adventurous knowing in many cases that if we get into a jam, there is usually the option of being rescued and helped. Although remote locations and various activities (climbing, diving, etc.) provide the possible element of 'no possible rescue', with most Earth-based excursions there could still be the possibility of rescue. However, in space this is not likely, and as we venture out further from Earth in the future a rescue will most likely not at all be possible. In lieu of this extremeness, stressors known to the space environment include those such as no atmosphere, water, and food; extreme temperature variations; altered gravity (bone and muscle loss); high radiation risks; and altered electromagnetic fields. Harrison et al. (1989) further classifies these and other stressors into two primary categories: 'chronic' stressors (danger, boredom, limited supplies and equipment, isolation and confinement; noise and vibration; cardiac deconditioning; and apprehensions about life support); and 'discrete' stressors (extravehicular activities, disasters such as fires and malfunctions, and the arrival of new crewmembers). Because of these stressors, as well as the tensions that may develop with crewmembers during prolonged space or space analog missions, there has been a strong emphasis on crew selection criteria in search of potential crewmembers having the 'right stuff' (Bishop et al., 2006a; Leon, Atlis, Ones, & Magor, 2002; Suedfeld, 2005). However, Bishop et al. (2006a) argues that to date attempts to develop such selection criteria have been inadequate. Furthermore, inter-group conflicts have been documented in both space and space analogue environments. A 4 ½ year joint study of the Shuttle-Mir Space Program (SMSP) by Russian and United States scientists (Kanas et al., 2001) documented conflicts within crews as well as persistent problems between crews on-orbit and mission control. In an effort to improve selection criteria to find the most suitable candidates, selection protocols have transitioned from the sole reliance of 'select out' criteria (selection based on desirable psychopathology) to inclusion of 'select in' criteria (selection based on desirable psychological characteristics). As a result much recent research has been focused on developing 'select in' criteria in order to identify the most suitable candidates (Bishop et al., 2006a; Connors, Harrison, & Akins, 2005; Palinkas, 2009; Stuster, 1996; Suedfeld, 2005).

With regards to human survival in extreme environments numerous bodies of research have noted that psychological and physiological stress present a serious challenge to individuals exploring such environments. On Earth, human performance in extreme environments has been studied extensively with regards to psychological and physiological stress and human adaptations, as well as with regards to group dynamic development (Armstrong, 2000; Houston & Cosley, 2004; Leon et al., 2002; Palinkas, 2009). There have also been studies carried out that have noted the resilience of humans who were exposed to incredibly high amounts of environmental stress (POWs, Holocaust survivors, etc.) (Suedfeld, 1997). Furthermore, although there has been considerable concern for the psychological and physiological well-being of astronauts partaking in a long space sojourn (i.e. to Mars), studies have also indicated that exposure to these same stressors in many cases has been a very positive experience for many individuals as they were more opened to the beauty of the landscapes that surrounded them, problem-solved more effectively and efficiently, and were healthier after the experience (Harrison et al., 1989; Houston & Cosley, 2004; Leon et al., 2002; Suedfeld, 1997, 2001).

Linking Past Expedition Findings To Present Day Space Expedition Efforts

Past expeditions and crew performance. There have been many past expeditions both here on Earth as well as those carried out in space, which provide useful documentations for analysis and consideration with regards to planning for long-duration missions to the Moon and Mars. Such past Earth-based expeditions include the Lewis and Clark Expedition (1803-06) and the Magellan Round The Globe Expedition (1519-22) analyzed extensively by Allner and Rygalov (2006), the numerous Antarctic expeditions extensively analyzed by Stuster (in *Bold Endeavors*), and many other literary reviews such as those by Palinkas and Suedfeld (2007). Although there are many other expeditions to consider, these particular missions offer scientists an opportunity to learn from both the successes and failures during each expedition experience. Although these three examples may seem to far beyond the present day scope of technological advancements, the challenges each expedition faced were comparable in many ways to the challenges astronauts are faced with in returning to the Moon and then eventually traveling to Mars. As distance from Earth increases, so do the uncertainty and risk factors associated with crew performance and group dynamic development. Using these past expeditions to gain insights for future space mission developments, may indeed provide researchers with knowledge that may help us learn how to best survive as a human species on other celestial bodies in our solar system.

Recent space analog site mission efforts. More recently researchers have tried to develop and carry out research here on Earth in what are known as space analog environments. These environments offer researchers an opportunity to study various aspects of group dynamic development and interaction (Harrison et al., 1989) while also testing out a variety of space related considerations with regards to workload management efforts, human/machine interfaces, etc. Although there is usually some element of control in the experiment, the realism of mission duration and possible dangers associated to the remoteness of the location lends itself a more valid study variable for comparison to the 'extreme' nature of the space environment. Some such environments that have been established as space analog sites here on Earth include the following: BIOS-3 and BioPlex; Biosphere-2; NEEMO (Project Aquarius); SFINCS99 (a Russian study that lasted ~ 240 days); Mars analog site locations (The Mars Society's various Mars Desert Research Station locations around the globe); and the upcoming Mars 500 Study (a Russian study anticipated to last ~ 520-700 days).

Research Findings From An Analysis Of A Past Expedition (Lewis And Clark Expedition, 1803-06): How Humans Interact And React To Extreme Environments As An Individual And Group During Long-Duration Missions

Overview of the expedition

Relation to long-term space missions. The Lewis and Clark (L&C) Expedition has recently been analyzed for consideration as a space analog for future space missions to the Moon and Mars, given the nature of the expedition and the various similarities of the mission to those that have been carried out in space (Allner & Rygalov, 2008) This analysis found the L&C Expedition to be a 'blind' endeavor in the sense the crew were lacking pertinent information and knowledge about various factors necessary in making their mission a safe and successful one. A comparison of data collected from the L&C Expedition to research conducted separately by Nechaev et al. (1998) and Gushin (2005), was analyzed by Allner and Rygalov (2008). This analysis identified the following common tendencies between the L&C Expedition and space research findings: uncertainty factors; expedition duration; leadership and crew selection; considerations of supplies necessary for the expedition; In-Situ Resources; and survivability and adaptability skills.

Uncertainty Factors During The Expedition. The mission of the expedition team, as set fourth by U.S. President Thomas Jefferson, was to "explore the Missouri River and any other combinations of water ways that would provide a gateway of commerce and trade across the continent to the west coast" (*Discovering Lewis & Clark,* 1998). In pursuing this endeavor, the crew would be faced with many factors which would make the mission 'blind' or unpredictable in many respects, creating high levels of uncertainty requiring the leaders to make decisions where the outcomes would not be known until they moved forward on those decisions. Factors associated with uncertainty included: "climate, geography, Natives, food re-supply availability and species they would encounter after the winter they spent at Ft. Mandan (located near present day Washburn, North Dakota)" (Allner & Rygalov, 2008, p. 1958). Furthermore, the mission lasted more than two years and took place in a remotely confined and high-perceived risk environment that produced huge stresses and everyday challenges on the crew (Allner & Rygalov, 2008). The remote confinement associated with the Expedition was associated with the tight living quarters the crew endured on their Keelboat while navigating the Missouri River, as well as the time they spent wintering over at Ft. Mandan.

Expedition (Mission) Duration And Daily Journaling. Although the entire expedition lasted two years and four months in duration, at the time of the expedition none of the crew members knew what the exact duration would end up to be.

Therefore, those that were selected to participate understood it would be long and that the return home was contingent upon completing the mission objectives. Journals were kept daily by both Lewis and Clark and the Sergeants among the crew, and were used to keep careful record of daily events, discoveries, and overall group dynamic development. Connors et al. (2005) state in *Living Aloft* that, "most group dynamics research involves short-term groups, yet it is in long-term groups that we must understand in order to plan extended-duration space missions" (p. 178). Since the beginning of human space travel, several space exploration missions (up to the development of Skylab, the Russian space station Mir, and the present day International Space Station) were short-term in length (2-3 weeks in mission duration length).

Allner and Rygalov (2008) further state that:

> Recognizing that long-duration missions would best prepare us to go back to the Moon and Mars, a transformation of space mission research and planning took place. This transformation to more long-term space research provides justification for considering the L&C Expedition as an analog study for future space exploration. (p. 1962)

Leader and Crew Selection. Leadership and crew selection is a critical part of any mission; especially as the anticipated mission duration has the potential to increase. Jefferson's first appointed Meriwether Lewis, a U.S. Captain of the First Regiment Infantry, to lead the expedition. Lewis then appointed his good friend William Clark to serve as co-commander, promising him an equal leadership role.

Allner and Rygalov (2008) state that:

> After submitting this dual leadership request in writing to the War Department, Lewis was denied the right to have Clark legally share the leadership responsibilities of the mission. Although Lewis was officially the captain in charge, he kept his word to Clark and the two maintained equal leadership roles throughout the mission. (p. 1962)

An interesting fact regarding leadership selection was that Lewis was severely bipolar, and would exhibit "bouts of euphoria and depression" followed by periods of elation (State Historical Society of North Dakota, 2005). Although people of this era were unaware of the disorder and its implications, Jefferson and Clark were both aware of the depressive episodes that Lewis would experience.

Allner and Rygalov (2008) state that:

> Space missions of today and in the future would most likely not have chosen Lewis to lead this expedition. His known mental state would fall subject to 'select-out' criteria for astronaut selection, as mental stability is a critical factor associated with leaders chosen to command space missions. (p. 1962)

Nonetheless, Jefferson had observed and was aware of Lewis's depressive mental state. However, observing Lewis in settings where he was able to exhibit his skills and talents as a leader, Jefferson found Lewis to be remarkably driven (motivated) and an outstanding leader, and therefore chose him to lead the expedition.

With regards to crew selection, military personnel were primarily chosen to ensure the discipline necessary for carrying out orders. To be considered, all potential crewmembers needed to be "good hunters, stout, healthy, unmarried men, accustomed to the woods, and capable of bearing bodily fatigue in a pretty considerable degree"

(Snyder, 1970, p. 15). Allner and Rygalov (2008) further state that "similar to space exploration missions, there were desired skills for the expedition, which revolved around men who were hunters, carpenters, watermen, ironworkers, or gunsmiths" (p. 1962). Non-enlisted men were also selected but had to enlist in the army to be allowed to participate. Lewis and Clark also saw the importance of recruiting translators, which led to the recruitment of Touissant Charbonneau and his wife Sacagawea at Fort Mandan, as they would serve as translators for communication with the Natives they would meet along the way (Bakeless, 1964). "Although psychology tests were not the norm for expedition recruitment of that era, Lewis and Clark were as careful as possible in selecting-out men that exhibited signs of mental instability and unwillingness to work as team members" (Allner & Rygalov, 2008, p. 1962), two characteristics also found by Harrison et al. (1989) to be select-out criteria for individuals looking to participate in expeditions into ICE environments. Allner and Rygalov (2008) also state that those who "may have slipped through initial screening, which took place during the winter at Camp DuBois (located near present day Wood River, Illinois), were further screened during the first stretch of the expedition (from Camp DuBois to Ft. Mandan)" (p. 1962). This first stretch of the expedition lasted a little over six months; the time pressure having been noted in past studies as being a major factor leading to undesirable traits surfacing in individuals (Stuster, 1996; Suedfeld, 2005). One such example of a crewmember being selected-out after this first stretch was Private Moses Reed, who was court-martialed for running away from the crew and for stealing military property and was sent home with the Keelboat after the winter spent at Ft. Mandan (Allner & Rygalov, 2008).

Likewise today, even 200 years after the Expedition, the same basic considerations are being used for crew selection for polar and space missions. Findings from Connors et al. (2005) suggests that cultural diversity, emotional stability, personal attractiveness, technical competence, cooperativeness, social versatility, crewmember similarities and complementariness, crew size, and social compatibility are heavily considered when selecting a crew. Stuster (1996) also concludes that several space agencies have made use of 'select-in' and 'select-out' criteria for the selection of their astronauts.

Allner and Rygalov (2008) further state:

> 'Select-in' criteria strongly suggests that astronauts be highly skilled in many areas (psychomotor and cognitive performance), be psychologically stable, and be adaptable to ongoing changes and problems that will arise, while being able to maintain low levels of stress throughout the mission. (p. 1962)

Where early space pioneers were selected from a pool of highly trained military pilots, there have been many discussions and debates on whether military personnel (versus civilians, or a combination of military and civilian) should be chosen to be the first pioneers of a long-duration mission to the Moon or Mars (Allner & Rygalov, 2008). Therefore more research is necessary in order to validate which candidate (military or civilian personnel) would be most suitable for initial long-duration trips to the Moon and Mars.

Supply Considerations For The Expedition. Packing for the trip proved difficult, as 43 men needed different varieties of food, clothing, and daily consumables. With limited storage space on the ship for food supplies, the men were expected to hunt for the majority of their food, although a generous "supply of flour, salt pork, salt and 193 pounds of dried soup were brought along" to be used when necessary (Edwards, 1999, p. 24). Allner and Rygalov (2008) further state that "medicine was also of large importance on the trip as it would be inevitable that someone would eventually get sick" (p. 1963). Each crewmember carried their own medicine along with a rifle, gunpowder, fishhooks, knives, flints to set fires, flannel cloth, woolen overalls, candles, ink and paper for journaling, mosquito netting, and goods for the trade with the Natives (Edwards, 1999).

Future space expeditions to the Moon and Mars will most likely have to deal with similar considerations as the L&C Expedition, as both the cost and storage space for supplies will be important issues.

Allner and Rygalov (2008) state that:

> One such solution to the problem of supplies would be to use closed-loop systems that recycle water, oxygen, and food for the crew. This would not only keep initial launch costs/mass low, but could also resolve the problem of re-supply in route to Mars. (p. 1963)

Insitu-Resource Utilization. In-Situ Resource Utilization (ISRU) was also especially important given the initial mass/volume restrictions the crew was faced with. Skills were also necessary to acquire resources intra-mission as supplies became limited and/or depleted. Skills included those such as hunting and blacksmithing, as well as maintaining a crew composition that focused on team-building tendencies for adaptability and survivability (Allner & Rygalov, 2008). Other considerations included: the development of diseases and illnesses that required ongoing medical care and medicinal treatments; unknown geographical locations/obstacles; and environmental conditions (weather, etc.).

Survivability And Adaptability Skills. Survivability and adaptability skills were necessary for each crewmember as well as for the leaders of the L&C Expedition. "Being able to deviate from pre-set schedules was a vital part of being adaptable and flexible to the daily changes in the environment and crew group dynamics" (Allner & Rygalov, 2008, p. 1963). Allner and Rygalov (2008) further state that "higher level thinking and problem-solving skills would eventually become another aspect of survivability and adaptability" (p. 1963). There were two specific accounts of these skills being present on the expedition: one involved crewmember George Shannon, whose ability to design bullets out of wood allowed him to hunt for food and survive while he was separated from the expedition and out of ammunition (Bakeless, 1964). Another such account was when the crew devised a carriage device, made from cottonwood trees, to help transport their supply-filled canoes 18 miles around the Great Falls, a voyage termed "a portage" (Cavan, 1991, p. 82). They would even take advantage of the wind when possible and would hoist sails over the wagons to aid their progress.

Allner and Rygalov (2008) conclude that:

> Crews in route to Mars will have to fix and make modifications to equipment, and perhaps even make new equipment and devices from available spare parts and components, in order to keep things in working order for the crew's survival. This ability to adapt to a hostile environment will be essential with future space

missions, while also serving to combat the boredom of a long space sojourn. (p. 1963)

Tendencies of Group Dynamic Development.

Crew commitment to the mission objectives was another factor that is essential today with polar and space exploration initiatives. Factoring in the role of leaders is also of high importance, especially with the comparison to long-duration space missions. The ability of leaders to effectively communicate, lead, and maintain group dynamics where necessary, is critical when leading a group in a high-perceived risk environment with high levels of uncertainty (Allner & Rygalov, 2008). Harrison et al. (1989) provide similar support in their definition of and findings related to 'group dynamics'. Another similarity of the L&C Expedition to space missions is the use (navigation, limited supply storage considerations, etc.), and maintenance of transportation vehicles (the Keelboat, pirogues, and canoes) as space crews will need similar transportation vehicles (with similar storage considerations) to get to both the Moon and Mars as well as to various other exploration points of interest from the base camp that will be established on the surface of these celestial bodies (Allner & Rygalov, 2008).

Effective Countermeasures For Group Dynamic Development. The overall success of the L&C Expedition can be attributed to three main factors: effective countermeasures to prevent group conflict; high crew motivation; and leadership tendencies with group dynamic development (Allner & Rygalov, 2008). Where Leon et al. (2002) present findings of social conflict and decreased group cohesiveness over time during isolation in space analog environments, this was not the case as noted by the journals of Lewis and Clark. In considering the role that effective countermeasures play with group dynamic development we must factor in the notion that the L&C Expedition was an internationally-mixed crew, similar to the space crews of today and the future. What we have learned from past exploration involving culturally mixed crews is that despite careful selection of space crews there is a possibility that "prolonged isolation and confinement will bring long-standing prejudices to the fore" (Connors et al., 2005, p. 1966). Therefore, cross-cultural training should not only just a requirement of crewmembers selected to be a part of missions to the International Space Station (Leon et al., 2002) but also may serve as a countermeasure to prevent group conflict (Allner & Rygalov, 2008). Effective countermeasures that helped the L&C crew develop positive group dynamics included the following:

- Recruitment and selection of the crew
- Acceptance by the English crewmembers of the cultures and traditions of both the French boatmen that accompanied them up the Missouri River, as well as the various Native tribes they spent time with along their journey
- Intra-mission cross-culture training
- Strict military discipline and protocol in the early phases of the mission
- A daily work routine that was incredibly rigorous and tiring, which served as a form of physical exercise by which to alleviate stress
- Daily journaling requirements of the leaders and Sergeants (second in command)
- Occasional celebrations with dance and rationed alcohol
- Allowing a woman (Sacagawea) to participate on the expedition and help make critical decisions along the journey

- The requirement of proper hygiene throughout the expedition

Interestingly, although much intra-mission training (cross-cultural training) took place, there was little to no pre-mission ('pre-flight') training given to the crew. Furthermore, there was no in-flight support from any sort of 'mission control' during the expedition. While there was occasional correspondence from the crew to President Jefferson in Washington, the communication was one way only, and no support was provided from Washington, which could be considered as the expedition's 'mission control'. Considering the lack of the support the crew received in these two relative aspects (which have been found to be an essential consideration and aspect of today's space missions) the crew still maintained positive group dynamic development and stayed highly motivated throughout the duration of the mission.

Leadership tendencies with group dynamic development. The relationship between the leaders Lewis and Clark throughout the expedition was a very important factor in the mission success. Allner and Rygalov (2008) state that "although both leaders had different strengths and weaknesses they were each able to work effectively with different crewmembers in a successful effort to maintain group cohesiveness throughout the expedition" (p. 1967). When Lewis would enter into his states of depression, Clark would step up to fulfill his journaling duties and maintain the order of the crew. However, it was Lewis who had the more gentle approach necessary in reaching crew members on a personal level. "The respect and compassion the leaders had for one another also provided a strong example for how the crew was to conduct themselves with each other as well" (Allner & Rygalov, 2008, p. 1968), a suggestion also made by Harrison et al. (1989).

The leader's awareness of the role of ISRU was especially important during the winter at Ft. Mandan when food and supplies were almost depleted, and was essential in the development of positive group dynamics (Allner & Rygalov, 2008). As food supplies dwindled, the crew's willingness to learn from the Indians how to hunt for buffalo was critical (for food and making warm clothing), "as was their insight to blacksmith weapons that the Indians would only consider as a trade for corn" (Allner & Rygalov, 2008, p. 1968). Not only did these countermeasures allow them the ability to utilize available resources for survival, it also provided them with meaningful tasks by which the crew could escape winter boredom and depression. Each of these examples of leadership, which involved emotional control, adaptability, and the ability and motivation to maintain group harmony, were also the basis of research findings on successful leadership qualities conducted by Navy social psychologist Captain Paul D. Nelson at U.S. Antarctic Stations (Stuster, 1996).

Other leadership tendencies noted by Allner and Rygalov (2008) included those such as "the consistent, fair, and swift military discipline protocol for all crewmembers" (p. 1968). Not only did the leaders demand order and respect from their crew, they also very carefully monitored each crewmember's physical and mental state, another finding suggested by Harrison et al. (1989). "The care the leaders provided for Sgt. Floyd up until his death, and the care given to Sacagawea during her bouts with illness were examples of this" (Allner & Rygalov, 2008, p. 1068). From his past studies, Stuster (1996) suggested that caring for the health, safety, and overall well being of crewmembers was an admirable quality found in leaders of expeditions (especially leaders whose crewmembers exhibited signs of mutiny towards the leader). The leaders also exhibited clear and concise communication skills with their crew and with the Natives encountered along the way, a trait that Sexton et al. (2004) mentions is highly necessary for proper group functioning in extreme environments. Allner and Rygalov (2008) further state that "their persistence and willingness to push forward even when faced with diverse situations and conditions set the precedent for how crewmembers were expected to carry out their activities during the expedition" (p. 1968). Motivation seemed to be the key factor that the L&C Expedition utilized throughout the mission. "Both the leaders and the crew were highly motivated and driven to accomplish their goals and successfully complete their mission, regardless of any unfavorable situations or conditions that developed along the way" (Allner & Rygalov, 2008, p. 1968). Harrison (et al., 1989) note that a period of low morale tended to occur at the mid-mission phase, and from a meta-analysis of research in a wide range of isolated environments a tendency existed for negative emotions and behaviors to occur more in the third quarter of missions that were reported. From an analysis of the Lewis and Clark daily diaries this finding of negative emotions and behaviors was found more during the first quarter of the mission rather than the third, providing possible support for the premise that motivation was not only high throughout the mission but was likely a contributor to the overall success of the mission.

Methodologies Developed For Consideration In Future Space And Space Analog Missions

Distinguishable phase model. Allner and Rygalov (2008) state that "it has been shown in research aboard space stations and in remote confined locations that each mission lasting more than 3 months has its own dynamic" (p. 1959). This investigation will attempt to show that this dynamic can be applied to the L&C Expedition and described as consisting of a few distinguishable phases:

1. "Acute" phase (up to 3 months): adjustment to the novel… very busy situation
2. Intermediate phase (~ 3 to 4-6 months): increasing fatigue & decreasing m motivation; "asthenia"… psychosomatic/sleep problems, psychological concerns
3. "Long-duration" phase (> 4-6 months; - countermeasures): "asthenia" worsens, performance changes, perceptual sensitivities modify (visual, hearing,…)
4. "Final…the last period of the last effort" (~ last 2 months of mission): euphoria, hyperactivity…Delayed return from mission?!
5. Aftereffects of recovering from the mission…

Allner and Rygalov (2008) further state that "there is also an increased likelihood of mistakes (Fig. 1) that occurs at these various distinguishable phases, predominantly at the initial acute phase (the first two months) and final phase (the last two months). The distinguishable phase model further suggests that at the end of the intermediate phase and at the beginning of the long-duration phase a steady-state (with regards to performance) is reached which is marked with a decline and then an absence of mistakes until the middle of the long-duration phase, at which point fatigue begins to greatly affect performance and mistakes become evident again".

Mission mistakes analysis. Past space and space analog missions have documented crew performance errors throughout the duration of the missions. While there are many known causes of such errors (fatigue, workload stress, spacecraft/habitat malfunctions, stress due to outside interactions with Mission Control, home and family stress, low motivation, etc.), the fact remains that mistakes occur and may become a critical factor with regards to positive group cohesion. Past studies in space and on Earth have shown that mistakes and habitat/spacecraft problems affect missions and may ultimately become significant crew stressors as well as actively contribute to the degradation of positive group cohesion (Allner & Rygalov, 2008; Nechaev et al., 1998; Gushin, 2005; Linenger, 2000). Understanding when and why mistakes occur during missions carried out in Isolated and Confined Extreme (ICE) environments, as well as how mistakes affect overall group dynamic development, could provide very useful insights with regards to planning for future space missions to the Moon and Mars. If mistakes were indeed associated with the development of negative group cohesion and were more predictable at identified phases, then countermeasures could play a role in helping to maintain positive group cohesion throughout the mission.

Past mistakes data collection: performance on orbit (Gushin And Nechaev) vs. performance on Lewis and Clark expedition. From an analysis of mistakes made during the Lewis and Clark Expedition (L&C) Allner and Rygalov (2008) identified some interesting similarities with mistakes data from space missions noted by Gushin (2005) and Nechaev et al. (1998). Figures 1 and 2 show mistakes made by the L&C leaders as compared to space mission data. It is also important to note here that crewmember mistakes were originally analyzed and were not found comparable to the leader's mistakes (Allner & Rygalov, 2008). Additionally, given that the two L&C expedition leaders were the only two individuals that had been highly trained prior to the expedition in a similar fashion as astronauts are trained before space missions (Allner & Rygalov, 2008), they were considered comparable to the well-trained astronauts of today. Comparison of leader mistakes to those recorded by Gushin (2005)

(Figure 1) and Nechaev et al. (1998) (Figure 2) shows a variety of similarities as well as support for a distinguishable phase model suggested by Allner and Rygalov (2008). Analysis of the Gushin (2005) data to that of the L&C leaders (Figure 1) shows similarities in both the rise and fall of mistakes during the acute/intermediate phases and again at the end of the long-duration phase/beginning of the final phase, with a steady-state being achieved at the end of the intermediate phase and throughout most of the long-duration phase. This further supports the premise made by Allner and Rygalov (2008) regarding the prediction of where mission mistakes are likely to occur during a mission. The analysis by Nechaev et al. (1998) shown in Figure 2 provides similar results with regards to the rise and fall of mistakes noted during the intermediate phase and then again at the end of the long-duration phase and start of the final phase. Furthermore, Figure 2 also indicates a steady-state throughout most of the long-duration phase of the mission. The use of the past mistakes data (Figures 1 and 2), as well as the distinguishable phase model, provide a method by which to analyze the mistakes made and reported by Mars Desert Research Station (MDRS) Crew 52.

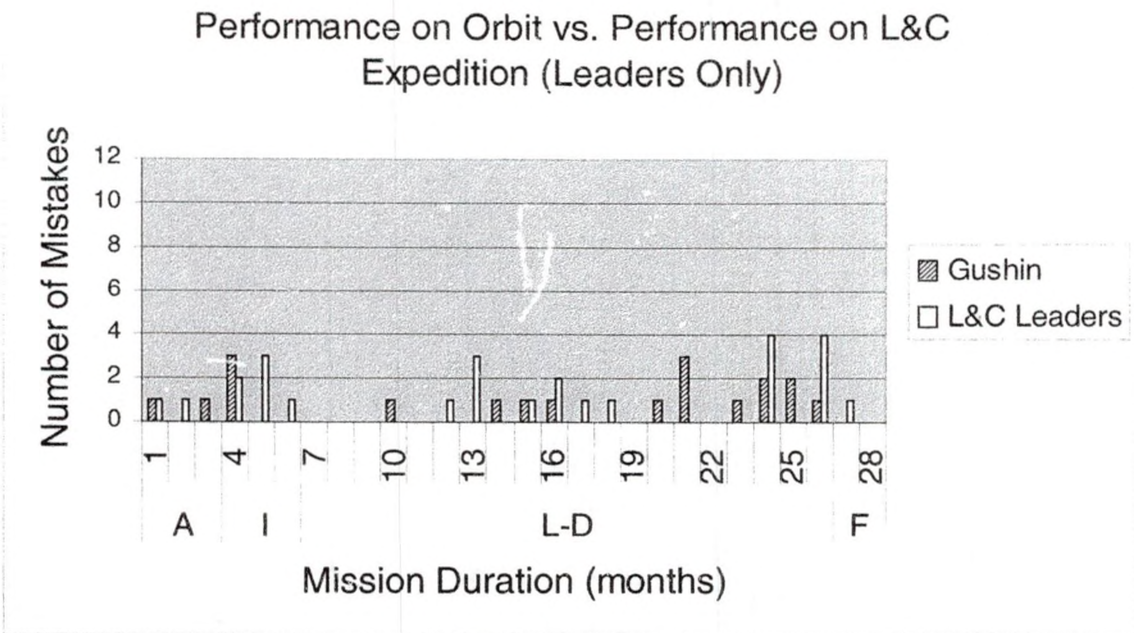

Figure 1. Performance On Orbit vs. Performance On L&C Expedition (Comparison of Gushin (2005) data to that of the L&C Expedition leaders). Cross-hatched bars represent mistakes from performance on orbit and the open bars represent the mistakes made by only the L&C Expedition leaders. Mission Phases are indicated as follows: A-Acute Phase; I-Intermediate; L-D-Long Duration; F-Final. While mission duration units are shown in months (for the purpose of following the phases of the 28-month L&C Expedition) please note that Gushin (2005) data was obtained from a 27-week mission (Allner & Rygalov, 2008).

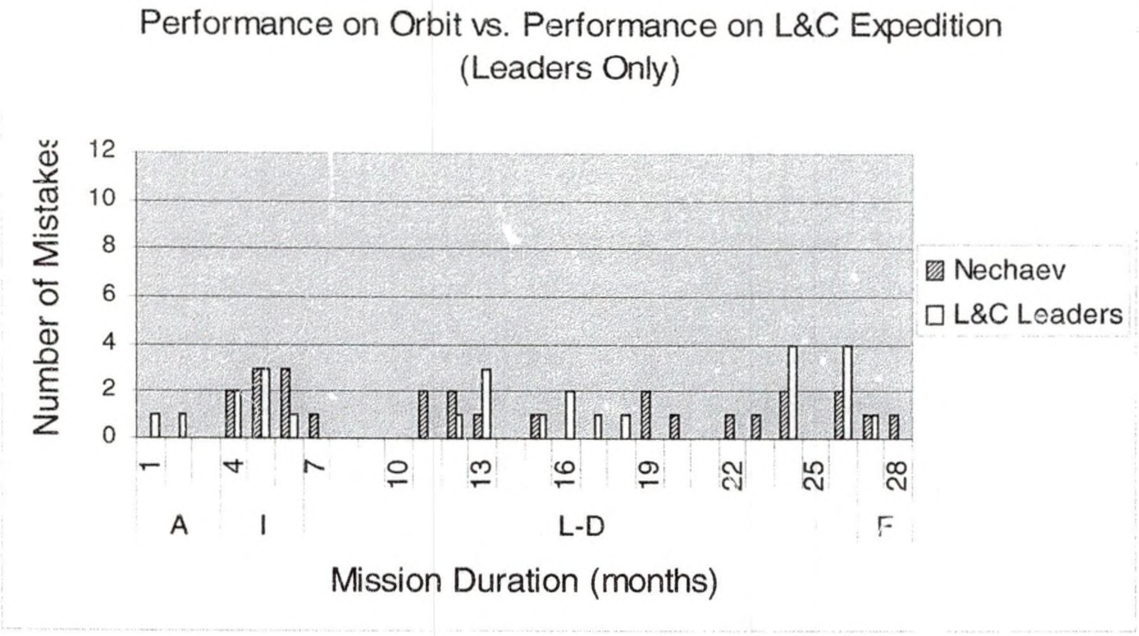

Figure 2. Performance On Orbit vs. Performance On L&C Expedition (Comparison of Nechaev et al. (1998) data to that of the L&C Expedition leaders). Cross-hatched bars represent mistakes from performance on orbit and the open bars represent the mistakes made by only the L&C Expedition leaders. While mission duration units are shown in months (for the purpose of following the phases of the 28-month L&C Expedition) please note that Nechaev et al. (1998) data was obtained from a 28-week mission (Allner & Rygalov, 2008).

Conclusions from the study. Although past studies have shown that winter-over crews have developed depression and decreased motivation due to the monotony and boredom of the isolation and confinement, this was not the case with the L&C crew (Allner & Rygalov, 2008). There were no noted occurrences of depression by the crew during the winter spent at Ft. Mandan and the crew found plenty to do to keep themselves busy and motivated. Allner and Rygalov (2008) conclude the following from their analysis of the L&C Expedition:

- Crew adaptability skills are possible and will be necessary for survival at many phases of the mission.

- The distinguishable phase model can be applied to the L&C Expedition, as well as to the data presented by both Necheav et al. (1998) and Gushin (2005).
- The mistake model may help to identify critical phases where mistakes occur so that effective countermeasures can be put in place to prevent such mistakes.
- Positive group dynamic development requires a healthy balance of strong (but flexible) leadership, high crew motivation, openness to human differences (such as culture, race, and gender), and the implementation of a variety of effective countermeasures at various phases of a mission.

Countermeasures from the L&C Expedition that are important future considerations:

- In-mission cross-cultural training considerations.
- Crew recruitment ('select-in' criteria) more focused on past/present performance as well as the ability to work in teams.
- Extensive daily physical exercise/workload to release the build up of stress.

Allner and Rygalov (2008) further suggest that the L&C Expedition be used as an analog study from which there has been two methodologies developed by which to analyze other space and space analog missions and crew performance aspects.

Focus Of The Thesis Study

This study investigates the effects of pre-mission communication and awareness strategies on competition and besting among crewmembers and crew psychosocial group functioning through an analysis of group environment, stress, and coping data, while looking at the relationship of this data to overall crew performance and mission mistakes made by a space simulation crew. Methodologies developed from an analysis of a past Earth-based expedition (the Lewis and Clark Expedition) will be explained in detail, as they were used to provide the crew of this study with critical pre-mission information. Findings from the space simulation can be used to gain insights into the impact of stressors on individual and group functioning under stressful conditions and the effectiveness of pre-mission communication and awareness. Furthermore, the findings may identify potential characteristics in individuals that would be most suitable for selection for space missions as well as to validate risks for crew performance errors and potential countermeasures.

CHAPTER II

RESEARCH FINDINGS FROM A PRESENT-DAY EXPEDITION AT THE MARS DESERT RESEARCH STATION (MDRS) IN UTAH, USA

Introduction

Several human factors have been identified and studied by researchers and have been found to contribute to both positive and negative group cohesion in missions carried out in extreme environments. Bishop et al. (2006a) states that mediating factors documented from the Shuttle-Mir Space Program (SMSP) studies include leadership style and flexibility, cultural and personality characteristics of crewmembers and size and structure of occupational subgroups. Bishop et al. (2006a) further states that, "personal characteristics may also define the role of stress and its impact on coping, performance, motivation, behavior, cognitive functioning and psychological well-being". ICE environments have been noted to produce inescapable environmental characteristics (e.g., imminent danger, noise, isolation, confinement, loss of normal sensory stimuli, etc.) (Bishop et al, 2006a; Sandal et al., 2006). Because of these inescapable environmental characteristics crewmembers must rely on each other for safety and survival, thus the need for highly adaptive group functioning and optimal behavioral health (Allner & Rygalov, 2006; Sandal et al., 2006). Part of this adaptive functioning and optimal behavioral health includes crewmember's ability to cope with stressors. If even the lowest levels of chronic stressors are not remedied with functional adaptation and/or countermeasures, they will eventually produce subjective symptoms of stress, errors in performance, increasing fatigability, altered mood states, increased rate of infections, and decrements in attention and cognitive functioning (Bishop et al., 2006a). Such subjective symptoms provide the basis by which a personality profile for 'select in' criteria can be established, where crewmembers would be more likely to respond by positive adaptation to the stressful environment and situations that may arise. Research by Sandal et al. (2006) suggested that although ICE environments produced a wide variety of psychological reactions by crewmembers, studies suggest one of four possibilities: "isolated and confined environments are no more stressful than other environments; highly motivated, self-selected individuals who volunteer for such long-term missions are capable of maintaining high levels of performance over long periods of time; motivated individuals simply do better than others; or psychological reactions are strongly affected by interpersonal and cultural factors that may vary across polar stations and expedition groups". Sandal et al. (2006) further summarizes that expedition studies have indicated that "positive mood prevailed over negative mood" over the duration of the mission.

Methods

Overview of the study. This psychological study carried out under two Institutional Review Board approvals; one from the University of Texas Medical Branch (UTMB) and the other from the University of North Dakota (UND) (UTMB IRB-04-124 and UND IRB-200808-025). The study was conducted on a six-person crew at the Mars Desert Research Station (MDRS) in Utah, USA. The crew (Crew 52) was the second crew of the 2006-07 MDRS field season, while being the first of four crews chosen to be a part of the NASA Spaceward Bound training program. Spaceward

Bound is a program for graduate students and teachers that was developed at NASA Ames from the model of the Mars Society Canada (MSC) and is funded by the Exploration Systems Mission Directorate *(ESMD)*. The goal is to enhance a training program that will simulate Mars exploration, serving as an analog site for physiological and psychological studies that can be used in crew selection screening processes; pre-mission communications and task assignments; mission operations and cross training; and post-mission activities.

Crewmembers were extensively briefed (both pre- and intra-mission) by the crew psychologist and were provided with past data (from Earth and Space expeditions) on group dynamic development and mission mistakes in conjunction with a distinguishable phase model (Allner & Rygalov, 2008) (which was explained earlier in the data sets from Figures 1 and 2). The purpose was to heighten crew awareness of mission mistakes at various points in the mission and where degradation of group dynamics (cohesion) has been known to occur. We hypothesized that by providing this data to the crew at the pre-mission phase, members might find a way to prevent mistakes (that might lead to group conflict) through self-awareness and self-assessment of their own mood, stress and coping strategies, mistakes made, and motivation. Therefore, the study focused on comparing the data obtained from a variety of administered psychology assessments to the mistake data reported by each of the members of the crew. Complete data assessments on personality, group functioning/identity, subjective stress and coping, and cognitive functioning were administered and analyzed from three of the six members of the crew at the pre-, intra-, and end-mission phases. Unfortunately, because of the time sensitivity of some of the data, various crewmember data had to be excluded from the study results due to complications in getting the data to electronically submitted on time. Subjective motivation data was collected (at the three mission phases) from all crewmembers, as this data was not time sensitive.

Subjects. The crew chosen for this Mars simulation mission was equally heterogeneous. Ages ranged from 27-33 and individual professional backgrounds included a diversity in engineering, biology, geology, psychology, and computer technology among others. The leader was male and serving his first mission as commander but had participated as a crewmember in a previous MDRS mission, which aided in the familiarity of the MDRS Hab and its overall operations. His background expertise was in project management, biocompatibility testing of space mission hardware, space biology experiment development, ground studies, and hyper-gravity research. The female geologist was a scientist who specialized in analyzing Martian and lunar planetary remote sensing data. Having had prior scientific research experience from participating in both an Arctic Expedition as well as fieldwork in Alaska, she also had an extensive past athletic background. The female engineer was a graduate student having much experience in the area of aerospace engineering, but no expedition background experience with regards to remote locations and 'roughing it'. The male psychologist was a secondary level science teacher, as well as a graduate student of space psychology and had participated on a prior research expedition to the Atacama Desert in Chile earlier in 2006. He also had a well-rounded past athletic background as well as extensive experience as a rescue diver. The female biologist had recently finished her Master's degree in Space Studies and although having limited expedition experience, she had a strong background in marine biology with an emphasis on greenhouse operations and maintenance. The male computer engineer had an extensive background in data communication networks and wireless propagation technologies, as well as experience in the design and construction of novel biomedical devices. Although he had never been on a science expedition, he had extensive past experience in the outdoors. The crew also included a pet cat (neutered) that served as a companion to previous crews as well as being used to assist with the rodent problem that had started to become an issue at the start of the MDRS 2006-07 field season.

Measures and Procedures

Crewmember personality assessments. Data analyzed in this study was collected from crewmembers two weeks prior to the start of the mission (pre-mission), baseline (day one of isolation), mid-mission (day 8) and at the end of the two week mission duration (day 14). The web-base battery of psychological questionnaires the crew was asked to complete pre-mission assessed various dimensions of personality as well as baseline stress and coping strategies. The battery included three primary assessment tools: the NEO-Personality Inventory (NEOPI-FFA); the Astronaut Personal Characteristics Inventory (AstroPCI); and the Six Factor Personality Questionnaire (SFPQ). The NEOPI-FFA (Costa and McCrae, 1991) has been the standard for global personality assessment for the last 15 years (Bishop et al., 2006a). The instrument assesses five dimensions of personality: Neuroticism (measuring mood stability, relaxation level, and ability to cope with stress; Extraversion (measuring affection, friendliness, and assertiveness); Openness to experience (measuring intellectual curiosity); Agreeableness (measuring honesty, good intentions, trust, and humbleness);

and Conscientiousness (measuring one's sense of capability and effectiveness, conscience and honor, and task completion).

The AstroPCI assessed two global categories: Achievement Motivation and Personal Orientation. Achievement Motivation measures included: Impatience and Irritability (measuring propensity for feeling time pressured, irritable and impatient); Achievement Striving (measuring goal directed behavior with clear desires for achievement); Mastery (measuring the desire to be in challenging situations); Work (measuring the willingness to apply oneself diligently); and Competitiveness (measuring the desire to compete with, or best, others). Personal Orientation measures included: Task Orientation (measuring self-assertiveness and instrumental traits); Expressiveness (measuring interpersonally oriented expressive traits); Hostility (measuring hostility and arrogance); Negative Verbal Aggressiveness (measuring verbal passive aggressive qualities); and Negative Communion (measuring self-subordinating qualities, submissiveness and individual concern for others carried so far that concern for self suffers).

The Six Factor Personality Questionnaire (SFPQ; Jackson & Tremblay, 2002) assessed various domains such as extraversion, agreeableness, independence, openness to experience, industriousness (measuring achievement, endurance, and seriousness) and conscientiousness.

Group environment survey (GES) scale assessments. At the mid- and end-mission phases of the mission participants were asked to complete a series of assessments measuring group identity/functioning, subjective stress and coping, and cognitive ability. The Group Environment Survey (GES) Scale (Moos & Humphrey,

1974) assessed 10 dimensions of group functioning with dimensions grouped into three separate categories, each with separately measured domains: 1) Relationship Dimensions, which included Cohesion (measuring involvement in and commitment to the group), Leader Support (measuring the amount of help, concern, and friendship the leader shows for other members), and Expressiveness (measuring how much freedom of action and expression of feelings are encouraged in the group); 2) Personal Growth Dimensions, which included Independence (measuring how much the group encourages independent action and expression among the group), Task Orientation (measuring the emphasis on completing concrete, practical tasks and on decision making and training), Self-Discovery (measuring how much the group encourages members' discussions of personal problems), and Anger & Aggression (measuring the extent to which there is open expression of anger and disagreement in the group); and 3) System Maintenance and Change Dimensions, which included Order & Organization (measuring the formality and structure of the group and the explicitness of rules and sanctions), Leader Control (measuring the extent to which the leader directs the group, makes decisions, and enforces rules), and Innovation (measuring how much the group promotes diversity and change in its own functions and activities).

Stress and coping assessments. For the collection of subjective stress and coping we utilized Sheldon's Perceived Stress Assessment and the COPE Inventory which was developed to assess a broad range of coping responses; some which were expected to be functional, while others dysfunctional (Carver, Scheier, & Weintraub, 1989). There were a total of 13 coping measures assessed, which were each grouped into three categories for analysis purposes: 1) Task Coping, which included Positive

Reinterpretation and Growth (staying positive and optimistic when faced with difficult situations), Active Coping (taking action to remedy a problem), Humor (using humor to lighten the stress of the situation), Suppression of Competing Activities (letting other activities slide to deal with a problem or priority), and Planning (making a step by step plan on how to solve problems); 2) Avoidance Coping, which included Mental Disengagement (taking part in other activities to avoid thinking bout or dealing with the problem), Denial (not acknowledging there is a problem), Behavioral Disengagement (reducing the amount of effort put into to resolving the problem), Restraint (resisting the desire to respond too quickly to a situation), and Acceptance (accepting the reality that something has happened and learning to live with it); and 3) Social Emotional Coping, which included Focus on and Venting of Emotions (expressing emotional feelings in an open manner), Use of Emotional Social Support (talking to someone about a problem to get sympathy from them), and Use of Instrumental Social Support (talking to someone about a problem to see how they would best suggest handling it or how they may have handled a similar situation in the past).

Cognitive functioning assessment (CogHealth data analysis). In analyzing cognitive ability (under daily stressors due to confinement, mission duration, etc.) a web-base cognitive assessment was administered at three mission phase points (beginning, mid-, and end- mission) for comparative and contrasting analyses of cognitive ability related to task performance over time, as well as when subjects were under a variety of stressors. The cognitive assessment measure administered to the crew members was CogHealth (a shortened version of CogState) which probes cognitive domains such as alertness, attention, working memory, spatial awareness, memory and executive function (Darby et al., 2002; Collie, Makdissi, Maruff, Bennell, & McCrory, 2003). CogHealth has been found to be a useful tool for the cognitive performance assessment of pilots (Westerman, Darby, Maruff, & Collie, 2001) and space crews, and since 2003, has been used at the Mars Desert Research Station (MDRS) in Utah (Bishop et al., 2006b).

Mission mistakes and habitat problems analysis. The premise for collecting mission mistakes data (from MDRS Crew 52) was derived from past studies carried out in space on the Mir space station (Nechaev et al., 1998; Gushin, 2005) and from an analysis of comparison the Lewis and Clark Expedition (1803-06) conducted by Allner and Rygalov (2008). The results of these past studies were shared with the crew both prior to and at the beginning of the mission, in an effort to provide pre-awareness of where and why mission mistakes have been found to occur throughout a mission. Collection of mistakes data was carried out every evening after dinner when each crewmember reported their own personal mistakes to the crew psychologist. Logged mistakes were identified as those which could cause any change in attitude, behavior, etc. that could become a potential disruption to positive group cohesion. Examples of such a defined mistake would include: not properly storing and caring for EVA equipment; leaving the cooking oven on; not properly following work protocol; small injuries due to a hurried mental state; etc. For analysis purposes, all crewmember mistakes reported and recorded were combined as a daily total for the crew.

Habitat problems encountered by the crew were also recorded on a daily basis, again each evening after dinner, but this was carried out with the group as a whole since the data was sensitive in nature and confidentiality was not necessary. The purpose of collecting this data was for the comparison to mistakes made by the crew as well as perceived stress the crew may have been experiencing during the mission. The analysis and comparison of these datum would be a later focus in the study.

Investigations Conducted At The MDRS

Study 1: pre-mission communication and awareness strategies study

Purpose. This study investigates the effects of pre-mission communication and awareness strategies for positive group functioning in extreme environments as well as suggestive countermeasures to maintain positive group dynamic development in ICE environments. The study is supported by both pre- and intra-mission management efforts, which included crewmember assessments at various mission phases (pre-, intra-, and end-mission).

Methods. Participants were administered assessments of personality, personal and group identity/functioning, subjective stress and coping, and subjective motivation. All participants were also provided information (pre-mission) regarding past research and tendencies of group functioning (data from Fig. 1 and 2), stressors, cognitive functioning, and mission mistakes from a mission phase analysis approach, to see if this would be a factor in positive group dynamic development.

Results

Diary materials and anecdotal data overview. Data collected and obtained by both assessment and journaling methods were both consistent and indicative of positive personalities desirable of expedition crews. Assessment data further indicated positive group cohesion and group interactions, along with supportive and strong leadership, all which led to positive personal and group experiences for crewmembers (Allner, Bishop, Gushin, McKay, & Rygalov, 2008b). Crewmembers all displayed low levels of competition while still reporting high motivation and satisfaction for the group dynamic development and the mission objectives that were completed. Journals kept by the crew psychologist indicated that the crewmembers all felt the pre-mission awareness of group dynamic development tendencies of past expedition crews helped in keeping the crew cohesive throughout the mission. They felt the raise in the level of awareness; both pre- and intra-mission, served as a positive factor in the overall positive group dynamic development of the crew (Allner et al., 2008b).

NEO-PI data. Figure 3 shows personality assessment data obtained from the crew prior to the start of the mission (Allner et al., 2008b). Data from the NEO-PI assessment indicates Members 1, 4, and 5 would be conducive to positive group orientation, while further suggesting that Members 2 and 3 would not be favorable to group interaction.

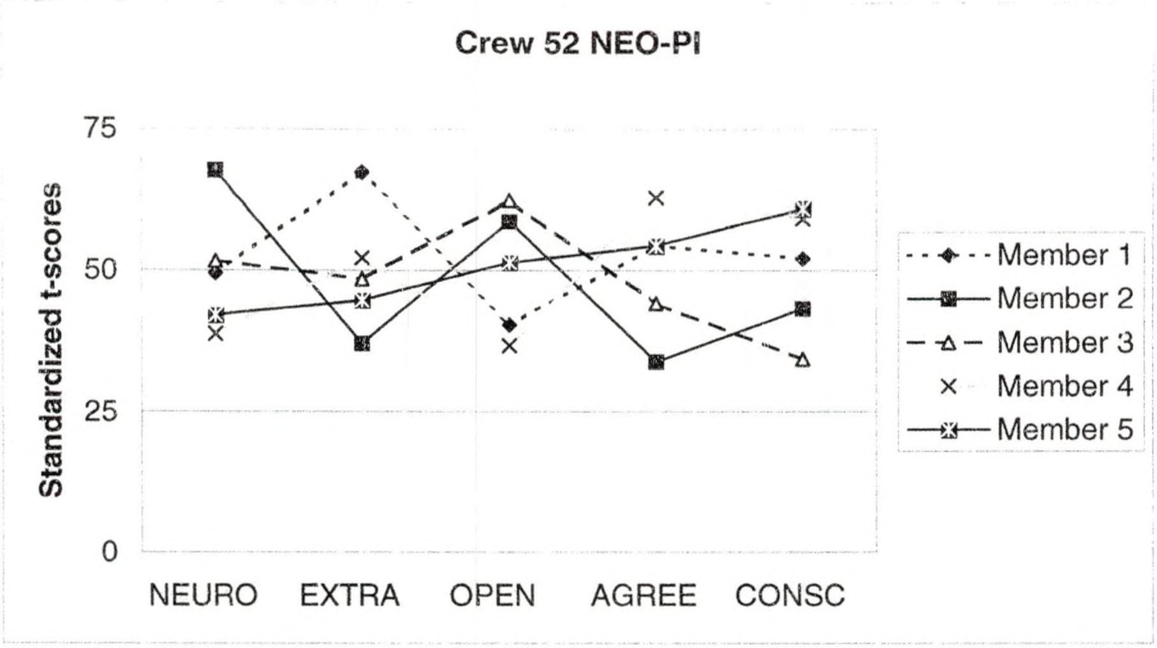

Figure 3. Personality Assessment (Crew 52 NEO-PI). (NEURO=Neuroticism; EXTRA=Extraversion; OPEN=Openness to Experience; AGREE=Agreeableness; CONSC=Conscientiousness) (Allner et al., 2008b).

Group environment scale data. Figure 4 shows Group Environment Scale (GES) data for personal growth dimensions (Allner et al., 2008b). Independence can be defined as how much the group encourages independent action and expression among members; Self-Discovery as how much the group encourages members' discussion of personal problems; Task Orientation as the emphasis on completing concrete, practical tasks and on decision making and training; and Anger & Aggression as the extent to which there is open expression of anger and disagreement in the group. Again Task Orientation data was not shown as there was no change in scores across time for all crewmembers (all received a raw score of 9). The GES data in Figure 4 shows member 4 to have had an increase in Independence while member 1 indicated a decrease (Allner et al., 2008b). With Self-Discovery member 1 showed an increase while members 3 and 4 showed no change over time. Where there was a small increase in Anger & Aggression with members 1 and 3, member 4 remained unchanged. Task Orientation data was collected but not shown on the graph above as all members scored a 9 on both the mid and end-mission assessments). Member 1 appears to have shown the greatest overall change with regards to growth dimensions while members 3 and 4 remained fairly consistent on measurement scoring from mid- to end-mission.

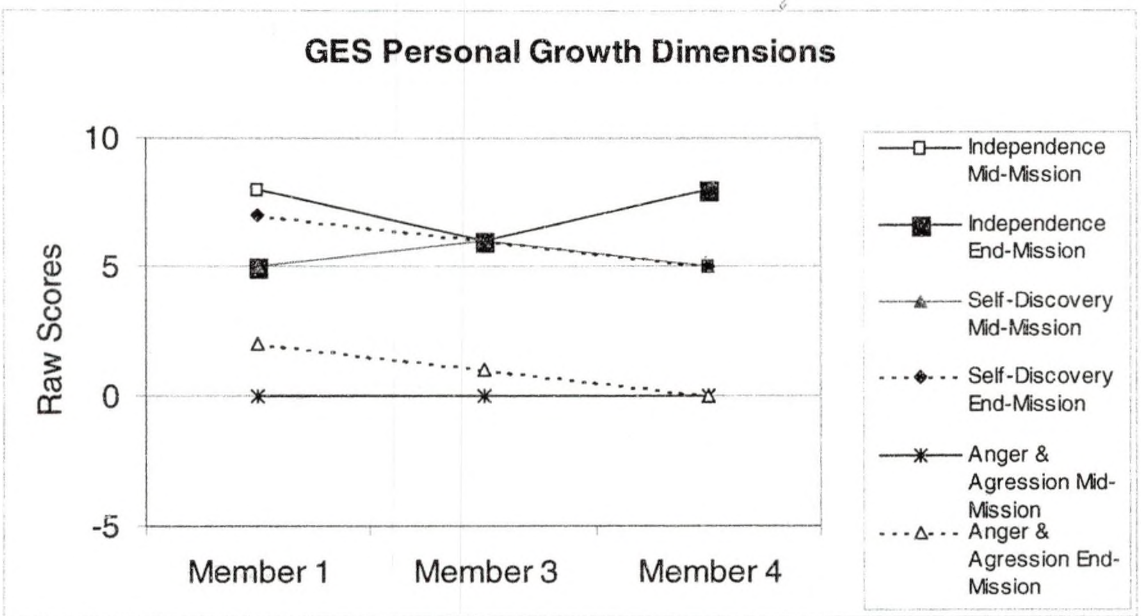

Figure 4. Group Environment Scale Data (Personal Growth Dimensions)
(Allner et al., 2008b).

Sheldon's perceived stress data. Figure 5 shows crew perceived stress, which was collected at three phases of the mission. The data indicates that all crewmembers experienced perceived stress across time (Allner, Bishop, Gushin, McKay, & Rygalov, 2008c). Members 1 and 3 showed large increases and decreases in their perceived levels of stress at the mid-and end-mission phases while Member 4 showed only slight deviations over time. Furthermore, Member 3 was the only crewmember that showed a decrease in stress at the mid-mission phase, while also having the highest baseline and end-mission stress scores of the three crewmembers. Comparing the baseline and end-mission scores only, Members 1 and 4 showed a slight decline in their levels of perceived stress. Allner et al. (2008b) suggest this may be evidence that the two crewmembers adapted well over time to the stressors that were present, supporting research findings regarding resiliency noted in many individuals who have wintered over in Antarctica as well as others who have experienced perilous stress in ICE environments on Earth (Suedfeld, 1997).

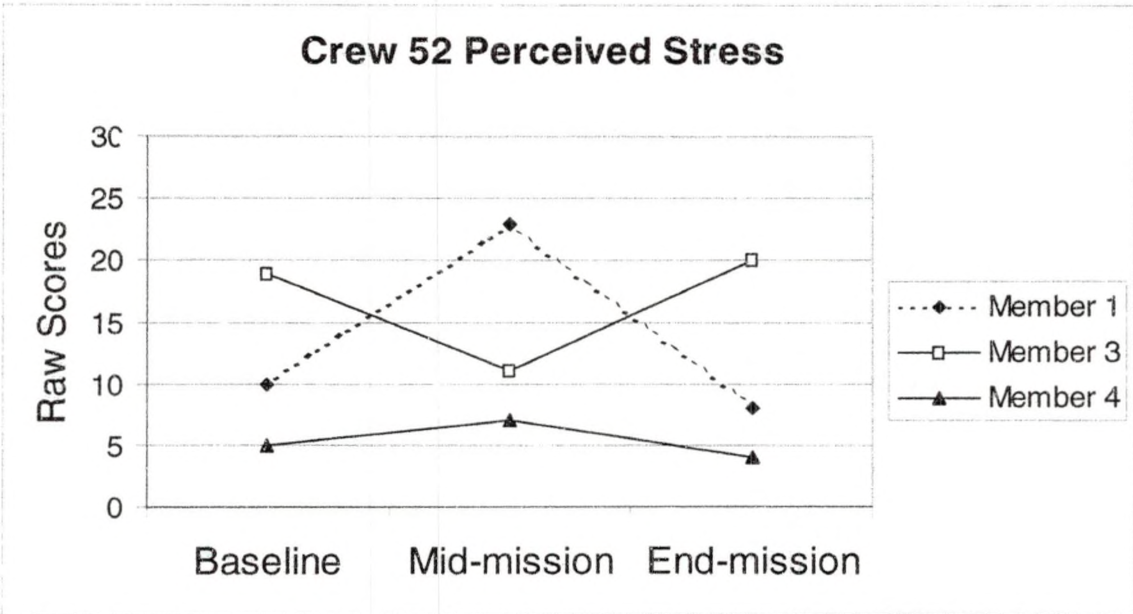

Figure 5. Sheldon's Perceived Stress Data.

Coping data. With the Avoidance Coping data (Figure 6) five separate dimensions were assessed: Mental Disengagement; Denial; Behavioral Disengagement; Restraint (refraining from acting out too quickly in response to various situations); and Acceptance (accepting a situation and giving in to the thought that it can't be changed). All members were fairly consistent with scores for Mental Disengagement, Denial, and Restraint, indicating scores that showed little change from mid- to end-mission. However, there were somewhat significant increases in Behavioral Disengagement from Members 3 and 4. Looking back at the stress data (Figure 5) Member 3 had shown a large decrease and then an increase in perceived stress from mid- to end-mission. Allner et al. (2008b) suggest this may explain why Member 3 had a significant increase in Behavioral Disengagement, a somewhat significant decrease in Restraint, and a very significant decrease in Acceptance.

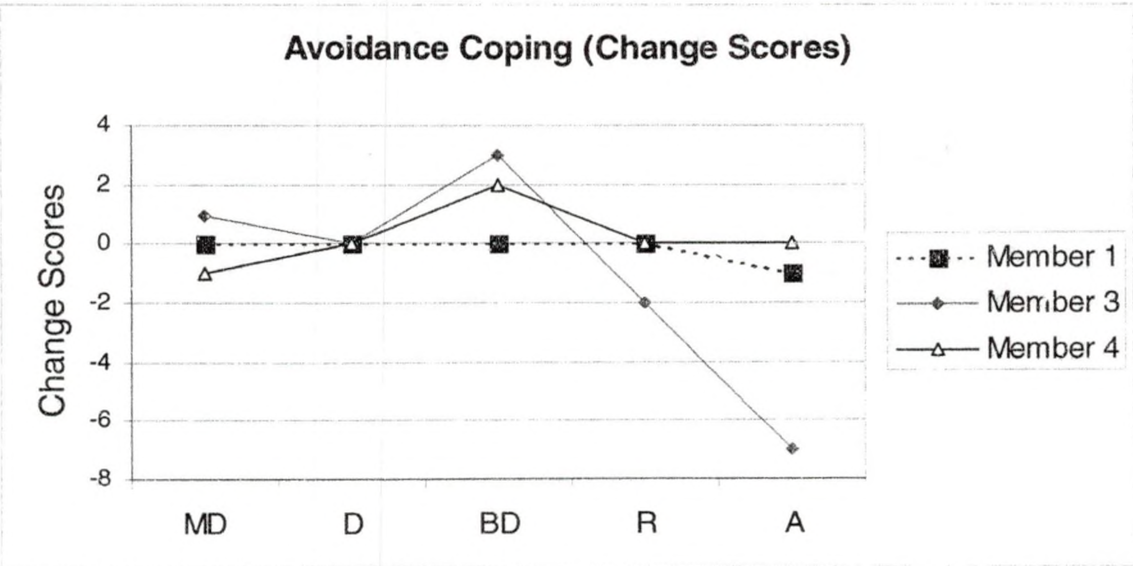

Figure 6. Avoidance Coping Data. MD=Mental Disengagement; D=Denial; BD=Behavioral Disengagement; R=Restraint; A=Acceptance. (Change Score = Mid-Mission Raw Score minus End-Mission Raw Score) (Allner et al., 2008c).

Conclusions. Overall the mission was a success, as the majority of mission objectives were completed during the two-week period. The group also maintained high levels of motivation and group cohesiveness throughout the mission, which led to positive group dynamic development and interactions. Although discrepancies existed in the data as compared to actual crewmember performance and behavior (noted by the crew psychologist) all crewmembers were highly motivated to get along and work together. Furthermore, crewmembers felt the pre-awareness of group dynamic development tendencies of past expedition crews was a major factor in helping promote the positive group interactions.

Study 2: competition and besting study

Purpose. This study investigates the effects of competition and besting among crewmembers in ICE environments. The term besting refers to when a person "bests", or competes against, a person in an effort to outdo the other person (Allner, Bishop, Gushin, McKay, & Rygalov, 2008a). Past studies have shown that this personal quality has had more of a negative impact on group functioning. Furthermore, the study investigates the effects associated with both pre- and intra-mission management efforts, which included crewmember assessments at various mission phases (pre-, intra-, and end-mission). Suggestions on how to manage competition and besting within a crew were investigated by implementing pre- and intra-mission awareness strategies as well as group participation in the development and implementation of countermeasures to manage crewmember tendency towards competition and besting to promote the development of positive group functioning.

Methods. Participants were administered assessments of personality, personal and group identity/functioning, subjective stress and coping, and subjective motivation. All participants were also provided information (pre-mission) regarding past research findings and tendencies of group functioning, stressors, cognitive functioning, and competition and besting.

Results

Diary materials and anecdotal data overview. Anecdotal data obtained from personal interviews with crewmembers strongly suggested that pre-mission discussions regarding competition and besting provided awareness that allowed crewmembers to continually self-assess to prevent this tendency from surfacing during the mission (Allner et al., 2008a). The assessment data results showed support for recorded diary materials which indicated crewmembers felt strongly that continual reminders of the besting concept, along with being allowed to participate in the development and implementation of countermeasures to manage competition and besting, was a key component in preventing it from entering the group dynamic development. Allner et al. (2008a) further suggest that assessment data and diary materials provided further support of the premise that competition and besting was never the cause of any crew conflict during the mission, and successful avoidance of this group fission factor was therefore maintained throughout the duration of the two-week mission.

Astro-PCI data. Figure 7 shows personality data results for achievement motivation taken from the Astro-PCI assessment (Allner et al., 2008a). The data indicates that member 1 scored low on mastery and work and somewhat high on competitiveness. Member 2 was high on impatience and irritability and achievement striving. Member 3 was high on mastery and work. And Member 4 was very low on impatience/irritability, achievement striving, and competitiveness, while also somewhat high on work. Member 5 was somewhat high on achievement striving, work and competitiveness.

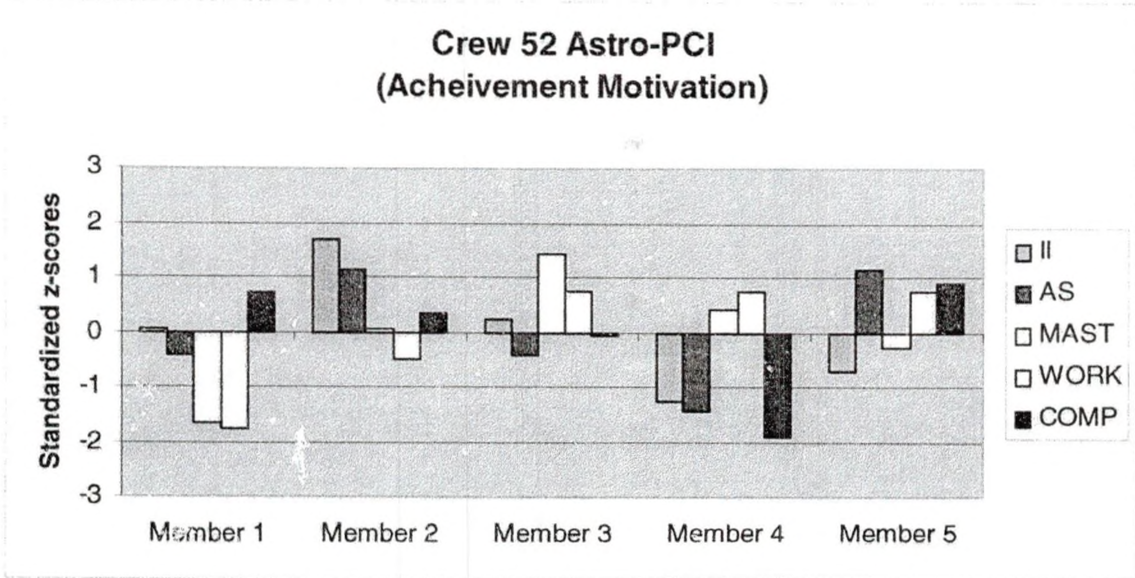

Figure 7. Astro-PCI Personality Assessment (Achievement Motivation). II=Impatience & Irritability; AS=Achievement Striving; MAST=Mastery; COMP=Competitiveness (Allner et al., 2008a).

Group environment scale data. Figure 8 (Allner et al., 2008a) shows results for expressiveness, which can be defined as how much freedom of action and expression of feelings are encouraged in the group (Moos & Humphrey, 1974). In Figure 8 the GES data shows members 1 and 3 as maintaining the same scores for expressiveness for both mid- and end-mission. Member 4 also showed an increase from mid- to end-mission. The results for Group Cohesion and Leader Support are not shown in the graph, as only those measures that indicated a change in score from mid- to end-mission are presented. However, it is worthy to note that all three members scored high for both dimensions, having received a raw score of 9 at both assessment periods. From the results from these three dimensions Allner et al. (2008a) suggest that the crew was highly cohesive with strong and consistent leader support, while also maintaining a consistent level of expressiveness.

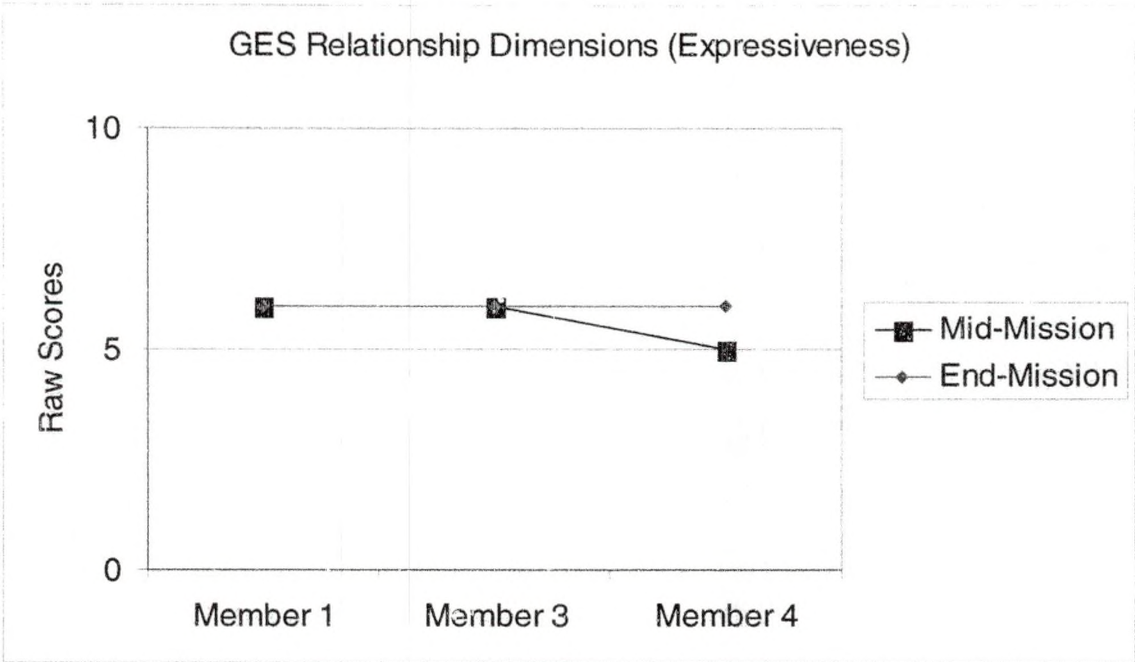

Figure 8. Group Environment Scale Data (Expressiveness) (Allner et al., 2008a).

Coping data. In analyzing the Task Coping data (Figure 9) five separate measures were assessed: Positive Reinterpretation and Growth (looking at a negative situation in a positive manner and growing from the experience); Active Coping (concentrating efforts and taking active steps to fix a problem); Humor; Suppression of Competing Activities (focusing on the problem at hand and not letting thoughts or other activities distract the process); and Planning (coming up with a strategy and steps to solve problems) (Allner et al., 2008a). Data results are shown as change scores (End-mission score minus mid-mission score), where a score greater than zero would indicate an increase in the score from mid- to end-mission, and so on.

Results indicate that most members found Positive Reinterpretation and Growth, Humor, and Planning useful strategies for coping with daily stressors (Allner et al., 2008a). This same finding was discovered by Suedfeld (1997) with studies conducted on POWs and holocaust survivors which not only showed the subjects resilience to the experience they went through, but also that they were able to grow from the experience and go on to lead normal, happy, and productive lives. Although Member 3 showed a large decline in Active Coping, all members showed declines in Suppression of Competing Activities. Allner et al. (2008a) suggest this may have been largely in part due to the numerous habitat problems that arose throughout the mission which diary materials confirm caused the crew to deviate from planned daily activities and research objectives, thus increasing crew workload.

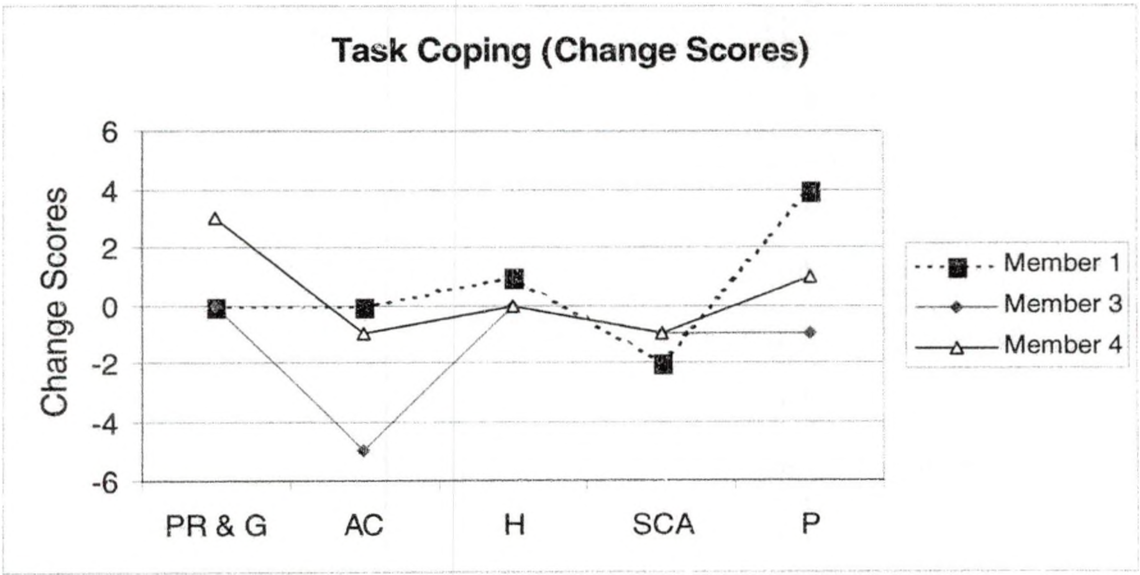

Figure 9. Task Coping Data. (PR&G=Positive Reinterpretation & Growth; AC=Active Coping; H=Humor; SCA=Suppression of Competing Activities; P=Planning). (Change Score = Mid-Mission Raw Score minus End-Mission Raw Score) (Allner et al., 2008a).

Conclusions. The crew psychologist reported besting was effectively managed throughout the mission, which may have been due to pre- and intra-mission strategies. Achievement Motivation data indicated members 1, 2, and 5 were avg/ high in competitiveness, while members 3 and 4 scored below avg/very low. All but one member scored avg/low on impatience and irritability, which may have been a factor in positive group functioning. Despite scores high in interpersonal competitiveness, which would predispose individuals to engaging in besting behavior, journaling data indicated that the crew responded openly. Crewmembers reported that their awareness levels of besting and the negative implications on past expeditions, helped create a level of self-awareness and assessment throughout the mission, which they noted helped them to consider certain actions before taking them. Since all members had competitive backgrounds, everyone participated in the development of competitive games and activities (countermeasures) the crew could engage in during relax-times. This was done in an effort to not suppress competition, but to promote it in a manner conducive to positive group cohesion. The data and diary materials strongly suggest this may have played a role in managing besting (Allner et al., 2008a).

Study 3: crewmember performance study

Purpose. This study investigates crew psychosocial group functioning through an analysis of group environment, stress, and coping data, while looking at the relationship of this data to overall crew performance (Allner et al., 2008c). Study 3 will revisit and cross-analyze data from Studies 1 and 2 in an effort to gain better insights into the impact of personality, stress, and coping on individual and group functioning (crew performance) under stressful conditions. Furthermore, the findings may identify potential characteristics in individuals that would be most suitable for selection for space missions as well as to validate risks for crew performance errors and potential countermeasures.

Methods. Participants were administered pre-mission assessments of personality, stress and coping, and personal motivation and orientation. In analyzing cognitive ability (under daily stressors due to confinement, mission duration, etc.) a web-base cognitive assessment was administered at three mission phase points (beginning, mid-, and end- mission) for comparative and contrasting analyses of cognitive ability related to task performance over time, as well as when subjects were under a variety of stressors. As previously mentioned, the cognitive assessment measure administered to the crew members was CogHealth (a shortened version of CogState) which probes cognitive domains such as alertness, attention, working memory, spatial awareness, memory and executive function (Darby et al., 2002; Collie et al., 2006).

Results

Group environment scale data. GES data results indicated very similar and consistent results with all crewmembers across time (Allner et al., 2008c). Looking back to Study 2, in Figure 8 we can see that all three members scored very consistent across time. Only Member 4 deviated from the other members, but increased in expressiveness from mid- to end-mission. The results for Group Cohesion and Leader Support are not shown in the graph, as only those measures that indicated a change in score from mid- to end-mission are presented. However, Allner et al. (2008c) mention it is worthy to note that all three members scored high for both dimensions, having received a raw score of 9 at both assessment periods. The results from these three dimensions suggest that the crew was highly cohesive with strong and consistent leader support, while also maintaining a consistent level of expressiveness (Allner et al., 2008c).

Looking back to Study 1, Figure 4 showed results for personal growth dimensions across time (data from the GES survey). Analysis of the Independence data indicates discrepancies among crewmembers: Member 1 had a decrease, Member 3 was consistent across time, and Member 4 had an increase. Data for both Self-Discovery and Anger & Aggression shows more consistency among crewmembers where scores either remained the same or increased across time. Diary materials provide further support for the Anger & Aggression data, indicating that the group never exhibited open expression of anger (Allner et al., 2008c). Furthermore, disagreement in the group was only evident at times during morning briefings when the crew was allowed to provide input on various decisions that needed to be made. However, Allner et al. (2008c) state the crew psychologist reported that all crewmembers acted very appropriate and professional about consensus decisions, never appearing to harbor bad feelings with regards to the outcome of the decisions. Overall, the data suggests that the crew responded more openly over time with one another, while not overly expressing anger and disagreement in the group (Allner et al., 2008c).

Sheldon's perceived stress data. Looking back at data in Figure 5 (Study 1), all crewmembers experienced perceived stress across time. Recapping on this data analysis members 1 and 3 showed large increases and decreases in perceived stress at the mid-and end-mission phases and Member 4 showed slight deviations over time. If we also recall, Member 3 was the only crewmember that showed a decrease in stress at the mid-mission phase, while also having the highest baseline and end-mission stress scores of the three crewmembers. The study 1 analysis further concluded that this may have been evidence that the two crewmembers adapted well over time to the stressors that were present.

Coping data. Throughout the mission the crew psychologist reported many stressors (Hab and environmental) just prior to and throughout the mid-mission phase (Allner et al., 2008c). Task coping data shown in Figure 9 (Study 2) indicated most members found positive reinterpretation & growth, humor, and planning useful strategies for coping with daily stressors. Furthermore, Avoidance coping data shown in Figure 6 (Study 1) had suggested that members showed the greatest change with respect to Behavioral Disengagement and Acceptance. Members also showed an increase in Behavioral Disengagement. Interestingly, the member's levels of acceptance (to situations that arose) showed the most negative change, while Mental Disengagement, Denial, and Restraint scores were mostly consistent from mid- to end-mission.

CogHealth data. The data collected from the CogHealth assessments were grouped into two categories for analysis purposes; one consisting of data results for all three phases of the mission (data from Members 2 and 4); and the other consisting of data for the first two phases (data from Members 1, 3, and 4) (Allner et al., 2008c). Allner et al. (2008c) suggest that the reason for such data presentation was due to the time sensitivity of assessment submissions at the various phases. Because of submission problems that occurred during the mission some of the data was either not successfully submitted, or was not submitted within the frame of time considered acceptable for analysis consideration. Nonetheless, the analysis of the beginning- and mid-mission data from members 1, 3, and 4 can be compared to the data results shown in Figures 4-8 which included the personality, stress, and coping assessments, as all data were complete across time for all three members.

Figures 10 and 11 show a comparison of data obtained from Members 2 and 4 at the beginning-, mid-, and end-mission phases (Allner et al., 2008c). One of the figures displays results associated with speed response (Figure 10), while the other indicates accuracy response (Figure 11). Interpreting the raw mean scores in Fig. 10, lower scores indicate shorter response time, the focus being on deviations in the scores from the baseline (beginning-mission) score. Here we can see both members displaying a subtle decline in performance (speed processing) over time. Member 2 displayed the largest deviation at the mid-mission phase, but slightly recovered at the end-mission phase. Although there was some recovery, the end-mission score was still lower than the baseline. Member 4 data showed very little change at mid-mission, but displayed a drop in score at the end-mission phase. Interestingly, both members had approximately the same beginning- and end-mission score.

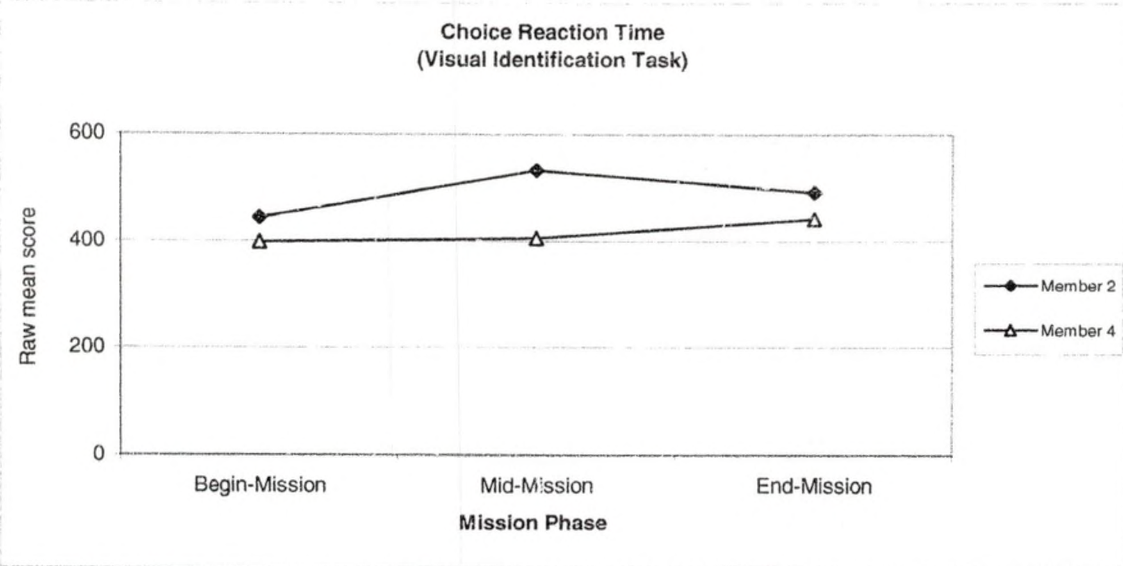

Figure 10. CogHealth Assessment (Choice Reaction Time—Visual Identification Task) (Allner et al., 2008c).

In Figure 11 the results of an assessment measuring accuracy response are shown. The data presented displays accuracy response, where a higher score is indicative of higher accuracy. What is interesting to note is that Member 2 has a sharp increase at the mid-mission phase followed by a sharp decrease at the end-mission phase. Member 4 results are much different, showing only a slight increase at mid-mission and then almost a return to the baseline score at the end-mission phase.

In understanding the possible reasons for such deviations from the baseline for Member 2 the NEO-PI data was considered, which showed this member as scoring high in neuroticism, low in extraversion, low in agreeableness, and below average in conscientiousness (Allner et al., 2008c). Furthermore, the Achievement motivation data indicated this member to be high in two domains: impatience and irritability; and achievement striving. Allner et al. (2008c) state these results may perhaps explain the drop and recovery in performance in Figures 10 and 11. Member 4 was practically the opposite of Member 2 with the NEO-PI data, having low neuroticism, high agreeableness, and high conscientiousness; while also scoring very low on impatience and irritability. Allner et al. (2008c) further suggest that the scores, being opposite of Member 4, may be factors of consideration with regards to better understanding crew performance.

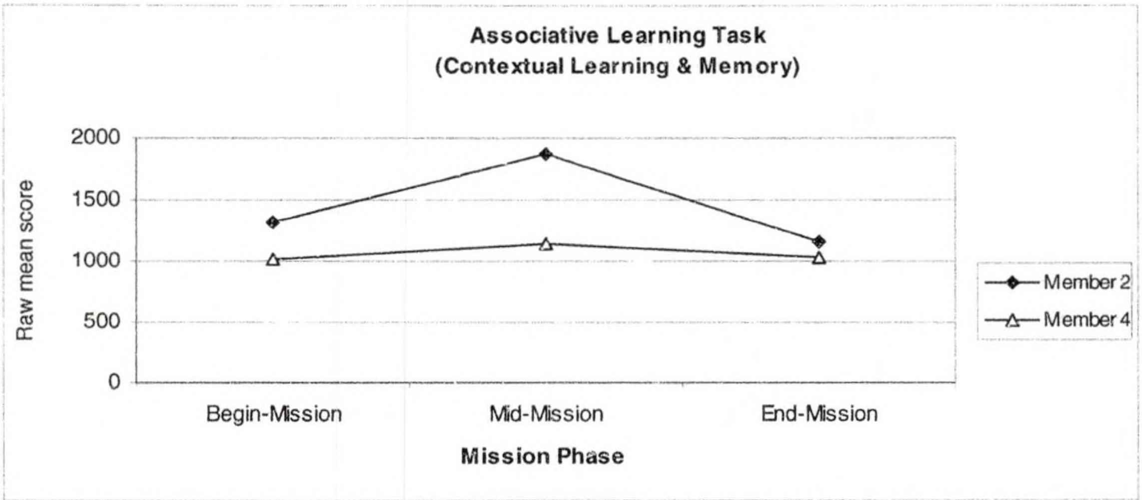

Figure 11. CogHealth Assessment (Associative Learning Task—Contextual Learning & Memory) (Allner et al., 2008c).

In analyzing CogHealth data from Members 1, 3, and 4 the focus was on the beginning- to mid-mission data. Results in Figure 12 display data measuring speed of task completion. Allner et al. (2008c) point out that the data indicates that all members showed a decline in performance from the beginning- to mid-mission phase. However, in reviewing the six domains, which assessed speed of task completion and processing, only choice reaction time showed a significant decrease in speed scores for all members from beginning- to end-mission. With all the other five domains assessed, the crewmembers all showed improvement from the baseline score. Furthermore, all three members' scores were parallel with regards to increase and/or decrease in speed scores with the other five domains assessed.

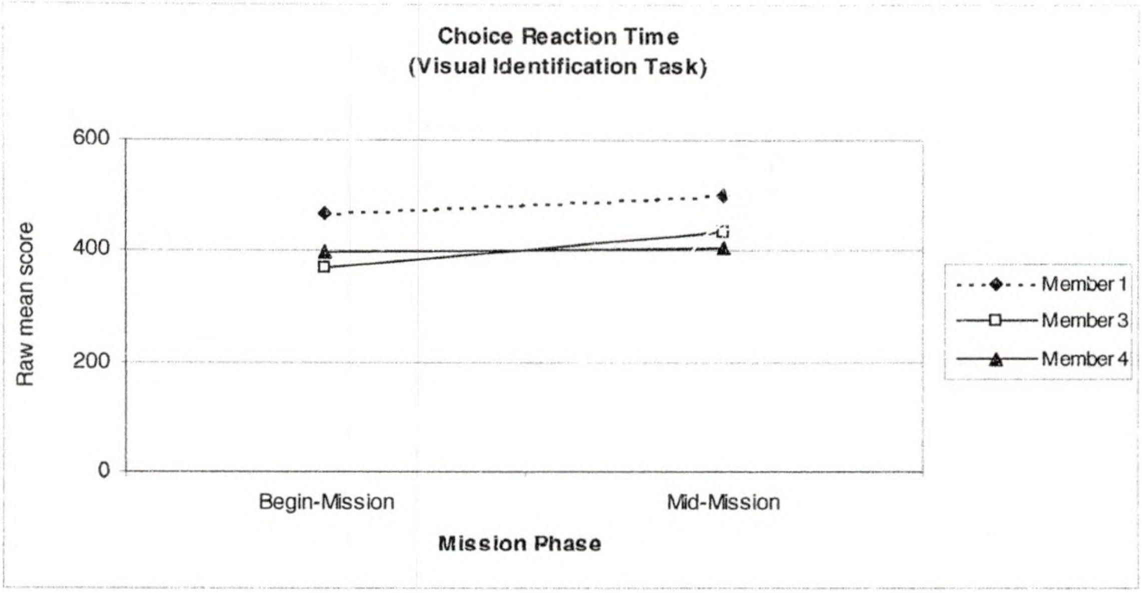

Figure 12. CogHealth Assessment (Choice Reaction Time—Visual Identification Task) (Allner et al., 2008c).

Looking at the stress response from Members 1, 3, and 4 (Figure 5) the differences in scores between Member 3 to those of Members 1 and 4, might suggest some strong differences in the performance scores provided by the CogHealth assessment. However, this is not the case. Figure 13 displays data measuring accuracy for all three members, indicating an increase in accuracy from beginning- to mid-mission, with both accuracy domains indicating that all members improved from beginning- to mid-mission (Allner et al., 2008c).

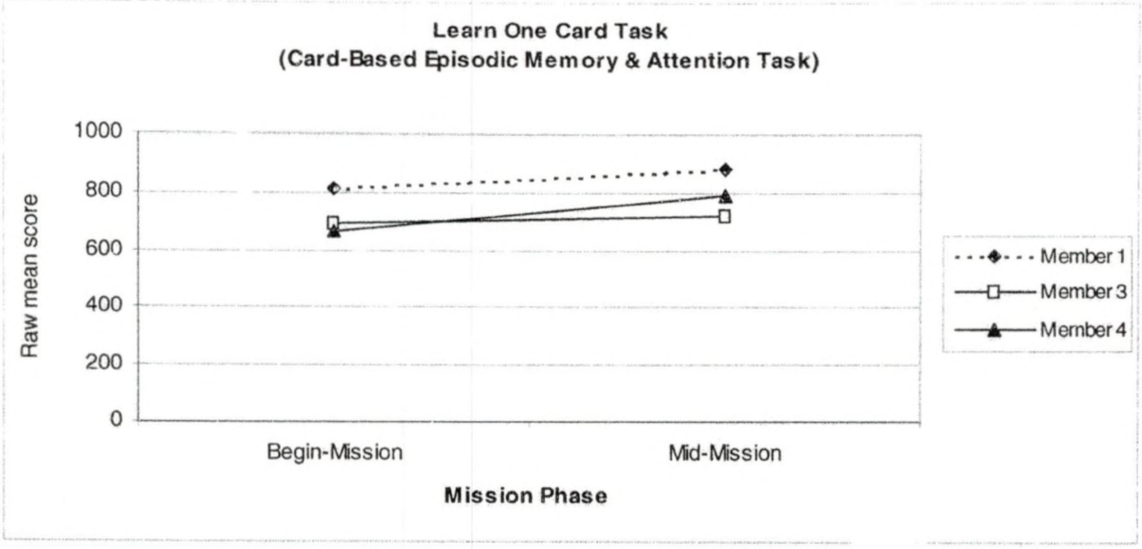

Figure 13. CogHealth Assessment (Learn One Card Task—Card-Based Episodic Memory & Attention Task) (Allner et al., 2008c).

Conclusions. The results from the GES data indicated the crew was highly cohesive with strong and consistent leader support, while also maintaining a consistent level of expressiveness. There were also no significant changes in crew performance from the beginning- to mid-mission phase for Members 1, 3, and 4, and across time for Member 4. Member 2 showed the only significant deviations across time with regards to speed and accuracy of performance on two measured domains, which Suedfeld (1987) has suggested may not be indicative of a cognitive degradation, but rather a motivation-related degradation. Looking at the stress data (Figure 5) we see Members 1 and 4 showed increases in their levels of perceived stress at various phases of the mission, while Member 3 showed a decline at the mid-mission phase. Furthermore, the coping strategy assessment indicated the rew responded positively to stressors that arose, heavily pursuing Positive Reinterpretation & Growth, Humor, and Planning as effective coping strategies for stress (Allner et al., 2008a). Allner et al.

(2008c) suggest that perhaps one conclusion as to why Member 3 showed such a large decline in perceived stress at the mid-mission phase was they responded better to the coping strategy than Members 1 and 4.

Study 4: mission mistakes vs. habitat problems study

Purpose. This study investigates crew psychosocial group functioning through an analysis of group environment, stress, and coping data, while looking at the relationship of this data to recorded crewmember mistakes and habitat problems. Findings can be used to gain insights into the impact of stressors on individual and group functioning under stressful conditions. Furthermore, the findings may identify potential characteristics in individuals that would be most suitable for selection for space missions as well as to validate risks for errors and potential countermeasures.

Methods. Participants were administered the pre-mission assessments of personality, stress and coping, and personal motivation and orientation overviewed in the previous three studies. These assessments and the data collected from them will be cross-analyzed with personal mission mistakes made by the crew as well as habitat problems reported daily by each crewmember.

The premise for collecting mission mistakes data (from MDRS Crew 52) was derived from past studies carried out in space on the Mir space station (Nechaev et al., 1998; Gushin, 2005) and from an analysis of comparison conducted by Allner and Rygalov (2008). The results of these past studies were shared with the crew both prior to and at the beginning of the mission, in an effort to provide pre-awareness of where and why mission mistakes occur throughout a mission. Collection of mistakes data was carried out every evening after dinner when each crewmember reported their own personal mistakes to the crew psychologist (M2). Logged mistakes were identified as those which could cause any change in attitude, behavior, etc. that could become a potential disruption to positive group cohesion. Examples of such a defined mistake would include: not properly storing and caring for EVA equipment; leaving the cooking oven on; not properly following work protocol; small injuries due to a hurried mental state; etc. For analysis purposes, all crewmember mistakes reported and recorded were combined as a daily total for the crew.

Results

Recorded crewmember mistakes. Fig. 14 shows crewmember mistakes, which were reported daily to the crew psychologist. Mission duration units are shown in days, rather than in weeks/months as analyzed by Allner and Rygalov (2008) (Fig. 1 and 2). Looking at the data in these two figures we can see a sharp rise and then fall in mistakes occurring at the beginning of the intermediate phase of the mission (days 3 and 4). There is also an increase in mistakes that occurs towards the end of the long-duration phase (day 12) followed by a slight rise and then fall during the final phase. Furthermore, there appears to be a steady-state (low incidence of mistakes) that is achieved throughout most of the long-duration phase. This data is supportive of past findings by Allner and Rygalov (2008), which are shown in Fig. 1 and 2.

Differences between the MDRS Crew 52 data (Fig. 14) and past data (Fig. 1 and 2) seem to lay mostly with the large occurrence of mistakes at day 5 (the highest of the mission) as well as the fact that there are no days where an absence of mistakes is evident. With regards to the mistakes made at day 5, journaling data recorded by the crew psychologist indicated that the crew awoke to an incredibly cold Hab, as the heater was not functioning (no electricity getting to the heater). In turn, the cold Hab temperatures had frozen the water line leading to the toilet, which disrupted the water recycling process of the Hab and presented potential sanitary concerns for the crew. The crew psychologist reported that these two Hab problems placed a considerable amount of stress on the crew, as well as further delaying the objectives and EVA mission that had been planned for the day. This may have been the cause for the unusual amount of mistakes that were reported on that particular day, as well as leading up to the increases in perceived stress reported by Members 1 and 4 in Fig. 5. Furthermore, the fact that mistakes were evident every day of the mission may be due in part to the fact that a two-week mission offers very little down time as there are many mission objectives to accomplish (which were mostly established pre-mission) along with those that arise intra-mission due to Hab problems, those added by Mission Control, overlooked objectives prior to the mission, etc.. However, given the short amount of time for the crew to develop a steady-state (low incidence of mistakes), the data in Fig. 8 suggests a steady-state was established during the long-duration phase where it was predicted it would.

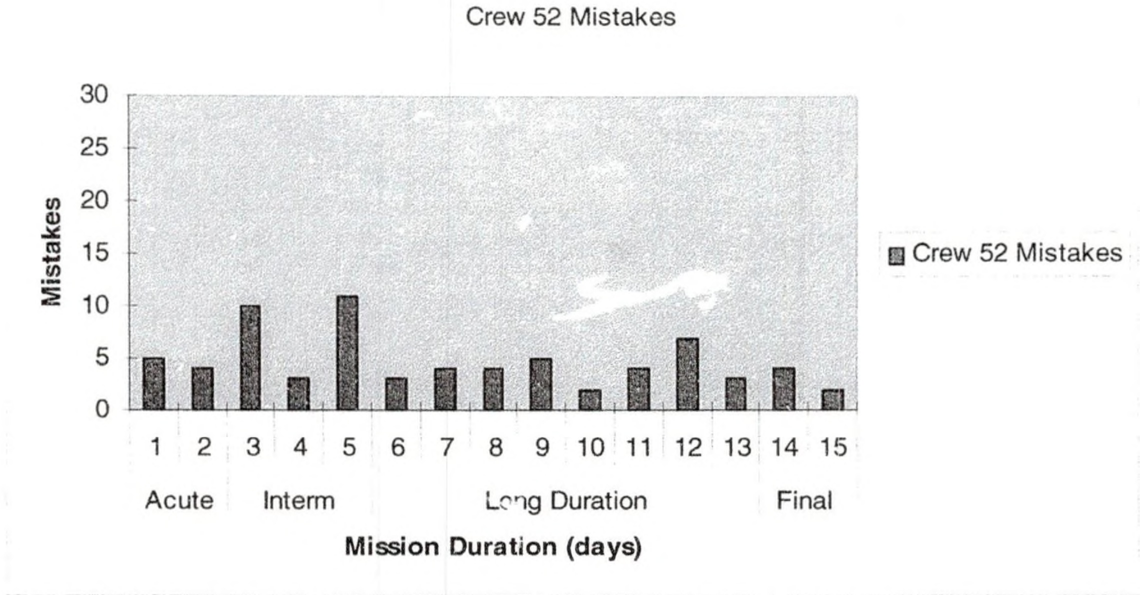

Figure. 14. MDRS Crew 52 Logged Mission Mistakes. (Crewmember mistakes reported daily to the crew psychologist. Mission duration units are shown in days, rather than in weeks/months as was analyzed with data from past space and space analog missions) (Allner & Rygalov, 2008).

Mistakes comparison to habitat problems. Allner et al. (2008c), in their analysis of crew performance (paper presented at the 2008 IAC), suggested that Habitat problems may have been a related factor to perceived stress reported by the crew. For this study, a comparison of mistakes made by Crew 52 to Habitat problems that arose daily during the mission is shown in Fig. 15. Analysis of the data appears to show a pattern starting at day 2. Where there is a rise in habitat problems (from day 1 to 2) the following day (day 3) an increase in reported crewmember mistakes is evident. Likewise, on days when there is a decrease in habitat problems (from day 8 to 9) the subsequent day (day 10) there is a decrease in mistakes. This pattern appears twice throughout the mission, possibly indicating a build up of crewmember stress, which could have led to this delay in mistakes being made. Furthermore, it is suggested the correlation between habitat problems and crew mistakes be looked at in more detail with future space and space analogue missions.

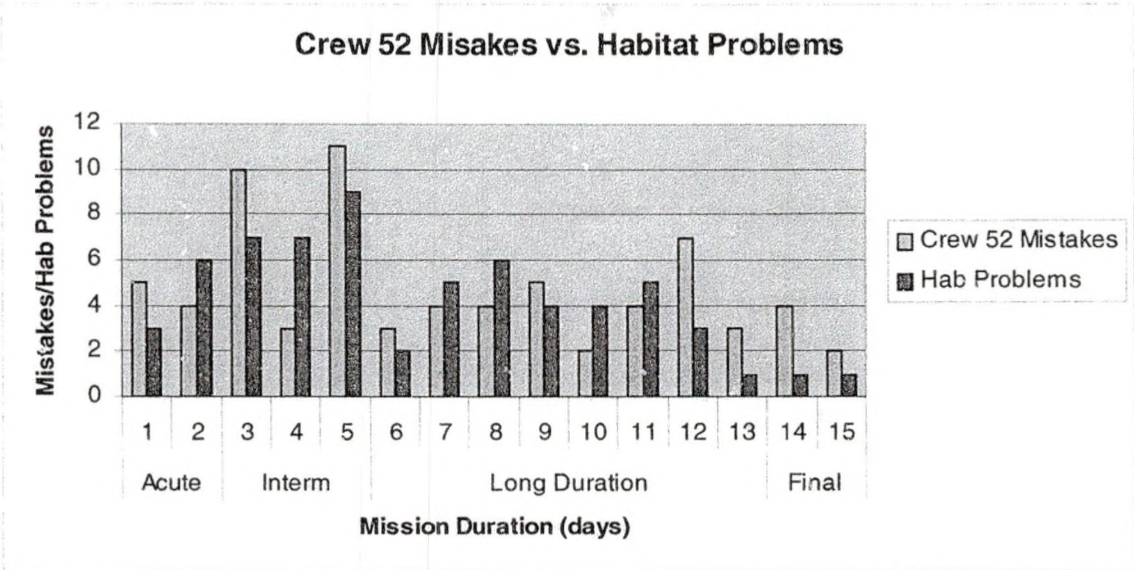

Figure 15. MDRS Crew 52 Mistakes vs. Habitat Problems. (Crewmember mistakes as compared to Habitat problems. Mistakes and Habitat problem data was reported daily by all crewmembers to the crew psychologist).

Conclusions. The results from the GES data indicated the crew was highly cohesive with strong and consistent leader support, while also maintaining a consistent level of expressiveness. However, there were also high levels of mistakes made at various mission phase points, as well as no reported absences of mistakes throughout the duration of the mission. Looking at the stress data (Fig. 5) we see all three members showed increases in their levels of perceived stress at various phases of the mission. Furthermore, the assessment of coping strategies showed the crew responded positively to stressors that arose, heavily pursuing Positive Reinterpretation & Growth, Humor, and Planning as effective coping strategies for stress. Although the crew made mistakes daily it did not seem to affect the development of positive group cohesion, as there is strong support for this in both the assessment data and the daily journals kept by the crew psychologist. Allner et al. (2008c) note that diary materials further indicated the numerous habitat problems most likely influenced cooperation among crewmembers, as they strived to solve the problems while working hard to stay on schedule with the completion of their research objectives. Looking back to data and findings in Study 3, it can be suggested there is a possible correlation of the stress data to habitat problems. In considering the results from Sheldon's Perceived Stress data (Figure 5) and comparing this to the noted habitat problems in Figure 15, responses from Members 1 and 4 provide possible insights into the relationship of habitat problems and crewmember stress. Although it is only suggested that habitat problems may have influenced crewmember mistakes in this particular study (Study 4), it can be strongly suggested that stress does affect performance which may lead to mistakes. In lieu of this correlation and consideration it is suggested this be further analyzed in the future. Furthermore, it can be concluded that although mistakes may play a role in the degradation of positive group dynamics, in some cases groups may become highly cohesive and more motivated regardless of mistakes made and stressors they experience. Past studies have found this motivation factor to be a strong contributor to overall mission success and group cohesion (Stuster, 1996; Allner & Rygalov, 2006) and therefore should not be overlooked.

Countermeasures discussed pre-mission that were put in place intra-mission were reported by the crew to have promoted positive group cohesion. Although countermeasures that work well for one crew may not work so well with others, the premise that they be discussed by the crew pre-mission (with all members participating) and then implemented intra-mission has been found by many expedition teams to promote positive group cohesion (Allner & Rygalov, 2008; Stuster, 1996). Diary materials and end-mission surveys indicated that crewmembers felt the pre-mission communication and awareness of past expedition and mission results, as well as the intra-mission updates and reminders, were very influential in the promotion of the positive experience they all felt they had experienced (Allner et al., 2008b). Therefore, it is suggested that future space and space analogue crews utilize this sort of pre-mission training in an effort to promote positive group cohesiveness both prior to, and during, a mission.

The effectiveness of pre-mission communication and awareness strategies (Allner et al., 2008b) appears to be positive, as the crew's overall performance was high, mission objectives were accomplished, habitat problems were resolved, and the crew maintained positive and high levels of group cohesion throughout the mission. However, the fact that the crew had a member involved in the mission (the crew psychologist) who understood the group dynamics and mistakes data history may have been a large factor in the outcome in the results (Allner et al., 2008b). Therefore, Allner et al. (2008b, 2008c) suggest that future studies look at the consideration of this factor and the study be administered to a crew that does not have a crew psychologist in the group, but one that administers the communication in person (pre-mission) and then from the outside (from Mission Control) during the mission.

CHAPTER III

SUMMARY OF RESEARCH FINDINGS FROM PAST AND PRESENT SPACE ANALOG EXPEDITIONS

Lewis And Clark Expedition

Distinguishable phase model. The distinguishable phase model was applied to the L&C Expedition and found to be useful as a tool by which to identify when and where mistakes may occur during a mission. This same model was applied to the MDRS study and reported by the crew to have played a positive role in the development of crew awareness to past tendencies of other crew, while promoting a sense of self-awareness and personal assessment that helped them each remain aware of their own tendencies as well as when and why they may occur intra-mission. It is suggested that this model be applied to more studies in the future for comparative analysis purposes.

Mistakes analysis. The mistakes analysis model was also applied to the L&C Expedition and when combined with the distinguishable phase model was found to be comparable in many aspects to past space missions carried out on the MIR space station (Allner & Rygalov, 2008). Data collected from the MDSR study indicates that the use of the distinguishable phase model was helpful in both pre-mission awareness efforts, as well as with providing a methodology by which to predict and monitor crew mistakes throughout the mission. Although both models were suggested for missions lasting 6 months or longer (future Moon and Mars mission consideration), the application of the models to a two-week MDRS mission could be considered for use in the present-day two-week Shuttle missions being carried out in space, as well as for the upcoming missions for astronauts to return to the Moon, as the initial missions are not likely to last in the order of months or years.

Mars Desert Research Station (Crew 52 Mission)

Pre-mission communication. The comparative analysis of the two models developed by Allner and Rygalov (2008) (the Distinguishable Phase Model and the Mistakes Analysis Model) served as the premise by which the MDRS crew was briefed pre-mission of past tendencies of space and space analog missions (mistakes, group dynamic development, and effective countermeasures). Both the collected data and crew accounts reported to the crew psychologist indicated that the crew responded openly to the models and ideas associated with the past data findings, while maintaining a high level of motivation throughout the duration of the mission (Allner et al., 2008a, 2008b). While the psychology, stress, and coping data indicated discrepancies in crew members scores, diary materials and anecdotal data indicated the group was highly cohesive. Furthermore, the consensus of the crew was that the overall experience was very positive, as they felt the pre-awareness of group dynamic development tendencies from past expeditions was a critical factor in promoting positive group dynamics (Allner et al., 2008b).

Competition and besting. Although high scores existed with interpersonal competitiveness, competition and besting was reported as having been effectively managed, as the crew reported their awareness levels of besting and helped to formulate a level of self-awareness and assessment throughout the mission (Allner et al., 2008a). Furthermore, the crew felt this helped them to consider certain actions before taking them. Allner et al. (2008a) stated that as a countermeasure to prevent besting the crew engaged in the development and implementation of competitive games and activities the crew could participate in. From the diary accounts and group interaction data, Allner et al. (2008a) suggest that group participation in the development of such countermeasures could have been a positive factor which resulted in such positive group interaction.

Crew performance and mission mistakes. Although there were possible correlations between the habitat problems noted by the crew (Figure 15) to the perceived stress data (Figure 5), Allner et al. (2008c) found there were no direct correlations between the perceived stress data and the crew performance (CogHealth) data from Study 3. However, a comparison of habitat problems and stress data to mistakes made by the crew in Study 4 (Figure 15) indicate a stronger possibility of more direct correlations, and therefore should be considered as a study methodology for the future (Allner et al., 2008c). Since past and current space missions have noted the many stressors present while living and working in space, it is important to understand the relationship between habitat problems and stress, as well the impact the two have on crew performance and group cohesion. It is suggested that more data be collected from crews working in similar analog situations, while applying the same methodology for data collection and analysis. However, it is further suggested that cortisol sampling be implemented for more accurate measurement of crew stress as compared to perceived stress reported through surveys conducted pre- and intra-mission. Past studies carried out at the MDRS by Bishop (2007) have shown discrepancies in perceived stress datum reported by the crew and actual stress measured via cortisol sampling methods, therefore it is suggested this method be integrated to show a more accurate measure of crewmember stress across time.

Group dynamic development. With regards to group dynamic development the crew encountered a large number of stressors due to habitat problems that arose while trying to juggle their science objectives. This did not seem to affect the development of positive group cohesion, as there is strong support for this in both the assessment data and the daily journals. Diary materials further indicated that the numerous habitat problems influenced cooperation among crewmembers, as they worked together to solve problems while working hard to stay on schedule with the completion of their research objectives (Allner et al., 2008c). Although Allner et al. (2008c) only suggested that habitat problems may have been the result of some decreases in crew performance, it is suggested this be analyzed further in the future. Furthermore, it can be concluded that although crew performance may play a role in the degradation of positive group dynamics, in some cases groups may become highly cohesive and more motivated regardless of mistakes made and stressors they experience. Past studies have found this motivation factor to be a strong contributor to overall mission success and group cohesion (Allner & Rygalov, 2006; Linenger, 2000) and therefore should not be overlooked.

Effective Countermeasures And Leadership For Future Space Missions

In furthering our understanding of the relationship between stress and coping, crewmember performance, and the development of positive group cohesion, the implementation of effective countermeasures is an essential part of minimizing stress, helping to keep crewmember mood and motivation high, improving overall crew performance, and promoting positive group cohesion throughout the duration of a mission. Oliver (1991) noted changes in the group morale dynamic over time during a winter-over experience by a crew at the McMurdo Station in Antarctica. Where Oliver (1991) shows the decrease in morale is noticeable (and perhaps predictable), this data would suggest that future crews put effective countermeasures in place at the mission phases where these declines are known to occur. With this in mind, the results of the MDRS mission indicated no direct correlation between perceived stress and crew performance from beginning- to mid-mission, as well as across time. However, due to findings from past studies regarding problems that have been known to arise from issues such as workload and boredom (Suedfeld, 1987, 2005) among others, it was suggested pre-mission that the crew develop its own countermeasures to put in place to remedy the effects of such issues should they arise. Effective countermeasures were put in place by the crew (pre- and intra-mission), and although the crew reported increases in subjective stress the psychologist reported the crew has highly cohesive throughout the mission. Therefore, it is suggested these countermeasures played a critical role in the development of positive group cohesion, and therefore should be further analyzed. In an effort to manage potential stressful issues the crew encountered (due to workload, boredom, etc.), the members of Crew 52 all participated (at both the pre- and intra-mission phases) in the development of countermeasures that would be put in place daily to help promote an overall positive experience during their time at the MDRS in Utah. Some such countermeasures included: taking turns preparing and cooking meals (doing so in partner pairs); utilizing yoga exercises as an evening group activity; playing games (board games, card games, etc.) in the evening before going to sleep; watching movies as a group; sharing and teaching others personal talents and skills; etc. Similar countermeasures were also found to promote positive group functioning in past exploration groups during both high workload times as well when times of boredom had existed (Connors, 2005; Stuster, 1996). This was also the premise behind an effort by the Ladenburg Collegium to develop a set of 'Golden Rules' for group interaction in high risk environments (Sexton et al., 2004). While the idea behind the study was to implement well researched countermeasures to help extreme environment groups function properly, one recommendation for leadership was that during high workload, the team leader should delegate all technical tasks to individual group members so they may focus all of their attention on managing the situation at hand (Sexton et al., 2004). A review of the Lewis and Clark Expedition and the MDRS Crew 52 found the leaders of both missions to have used a similar strategy during times of heavy workload and critical task situations. Furthermore, with crews that will be supported by a mission control of some sort, the leader will most likely not only be managing the situation, but also be communicating the situation to Mission Control to make them aware, as well as to get advice on how to best proceed.

Although most countermeasures were discussed pre-mission, the crew psychologist noted that the crew developed several other countermeasures intra-mission. One such countermeasure was the crew commitment to stop working each evening to eat dinner as a group. Where the crew came and went as they pleased for breakfast and lunch, dinner was highly valued as communal time. A wide variety of meals were prepared, with each crewmember taking on the role of making a meal of their choice for the crew. Everyone seemed to enjoy the meals, especially those which involved something new they hadn't tried or been exposed to in the past. In further support of this expedition finding, Stuster (1996) also states that food preparation is a critical factor contributing to the overall success or failure of a winter-over experience. During dinner time there was also no talk of work and the day's activities, commonly known as 'shop talk'. Instead, the crew talked about their personal lives, home, their hobbies, family, friends, etc. and with each passing day of the mission the crew found dinner preparation to be more and more relaxing, enjoyable, communal, and a time they all looked forward to each day.

Leadership also played a very critical role in the success of the MDRS mission. The leader of Crew 52 was a senior scientist and serving on his second mission to the MDRS. He did an excellent job of delegating jobs and leadership roles to the crew, while maintaining the role of mission leader for the crew. Anecdotal data obtained by Allner et al. (2008a, 2008b) showed that 'leader support' was consistently high from mid- to end-mission (GES data overview and Figure 8). While data for "leader control" varied across time for team members, diary accounts indicated that the leader exhibited proper control of leadership duties when and where necessary, while also knowing when to distribute (let go of) control, which is supportive of findings from Suedfeld (1987) which suggest the proper leadership is closely linked to the survival and success of the group. The fact that leader support was so consistent and high across time, provides evidence to support the diary material accounts related to leader control. Furthermore, the leader exhibited a good deal of credibility with regards to his technical skill and know-how related to the multitude of jobs that had to be carried out and managed, which Stuster (1996) has found to be a desirable characteristic in leaders that were supported by their groups. He also integrated a good sense of humor and was very involved in the group's social activities each evening, which were found to be admirable qualities found in past expedition leaders (Stuster, 1996; Allner & Rygalov, 2008).

Group Cohesion and Balance Personal Achievements and Mission Goals

Although group cohesion in Earth-based group activities (military missions, expeditions, sports teams, etc.) is essential in promoting group work and an overall positive experience for the participants, the necessity of this aspect in a space crew is not just important with respect to space missions, but will be critical with regards to international plans to have human space missions last 6 months in duration on the International Space Station (ISS). With present plans for the Shuttle to be retired in 2010, NASA will train its next class of selected astronauts (to be announced in the spring of 2009) for long-duration space flight missions (6 months and longer) on the ISS. In lieu of this, one very important aspect in relation to the development of group cohesion is the balance that must exist between personal achievements and mission goals. In other words, most people have personal agendas in life they pursue on an almost daily basis. At some point however, the question will arise as to whether these people will put their agenda first before all others that may exist; whether they can put their personal agenda aside for the goals of the 'team' or 'mission'; and/or whether they can balance the two and achieve both (integrate the two together) while at the same time maintaining good standing with the crew they are a part of. This balance is not an easy task, as many factors can come into play so as to make things very complicated indeed.

During the MDRS study, diary materials collected by the crew psychologist noted that this aspect of balance was discussed openly with the group at the start of the mission in an effort to create awareness of both the negative and positive implications associated with balancing/not balancing personal agendas and the overall mission objectives (Allner et al., 2008b). Almost all crewmembers were bringing personal research projects into the two-week isolation experience and yet there were overall mission objectives that were assigned to the crew by both NASA Spaceward Bound and the Mars Society. The psychologist noted that the crew did an excellent job balancing their personal goals and objectives and furthermore, every member that had a personal agenda of research to accomplish was willing at any time to put down their work to help another crewmember with any task/objective they needed assistance with. Past studies have indicated that this willingness to help others with work and research goals is a highly cohesive quality as the members developed an understanding of the concerns and approaches of others (Suedfeld, 1987). The psychologist further noted that this may have been a critical factor in the development of positive group cohesion, as all crewmembers stated their experience with the mission and their crew was a positive one (Allner et al., 2008a, 2008b, 2008c).

Throughout recent past and present-day space missions this balance has been different with respect to the two-week Shuttle missions and the 6-month ISS missions. With the two-week Shuttle missions the crew has a tightly packed agenda from launch to landing, while the long-duration missions (ISS crew) have a more steady pace to operate under where there is more relax time built into the day for personal activities and socializing. Having this extra time built into the day for space crews may be a large factor in the development of group cohesion as well as helping astronauts to balance personal goals and the mission objectives.

CHAPTER IV

SUGGESTIONS / RECOMMENDATIONS

Although it is suggested that these study methodologies be repeated both with a crew psychologist being a member of the expedition team as well as with this person being part of the crew's pre-mission training sessions (and then only an active member through communication and support from mission control), another approach can be considered to provide more precise data with regards to crew performance monitoring. Using the distinguishable phase model suggested by Allner and Rygalov (2008), along with an analysis of crewmember mistakes made daily during the mission, more accurate data could be collected which could be compared to data obtained by Allner et al. (2008c) from the CogHealth and perceived stress assessments, as well as from the habitat problems data reported daily by the crew Allner et al. (2008c) further suggest that "the mistakes data be collected having crewmembers document and report daily personal mistakes". The crewmembers would need to be briefed pre-mission of the importance of such collection of data, as well as being willing to participate in such a study. "The idea of their participation in the sharing of such information would be to create crew awareness and self-assessment, while also providing more accurate daily accounts of crew performance for analysis comparisons to reported habitat problems, CogHealth performance data, group cohesion data, perceived stress response, and coping strategies chosen by each crewmember" (Allner et al., 2008c). The term 'mistake' also needs to be better defined with regards to what would constitute a mistake and the rationale for using such a definition (Allner et al., 2008c). Further clarification of this definition is necessary for both the crew that would be providing such data for analysis purposes, as well as for researchers who would be cross-analyzing mistakes data collected from various missions.

With respect to astronaut selection, as space missions transition in the very near future to longer-duration missions (6 months and longer) and from 2-3 crewmembers on the ISS to 6, it is highly likely that selection processes will undergo some changes and the criteria by which astronauts are selected in/out will also most likely be modified. Past studies have shown that some of the most carefully selected and trained space crews have failed in their ability to get along and work through differences they have had. Missions of non-international and internationally mixed crews both have the potential to develop these problems with group dynamic development (Baranov, 2001; Pesavento, 2004). Connors et al. (2005) further supports the possibility that "prolonged isolation and confinement will bring long-standing prejudices to the fore" (p. 151), therefore both the selection and intra-mission support (psychological and implementation of effective countermeasures) will be essential to help keep crews highly cohesive. As these missions increase in duration and in crew size, and as the distance from the Earth increases for the mission, pre-mission training and planning will also be critical (as it has with past space missions). However, it is anticipated that the awareness and implementation of the psychological component will be of added value in order for the crew to provide their own onboard psychological support for one another, especially in the event that support from mission control is found to be either inadequate or unwelcome by the crew. The possibility of psychological support from mission control being unwanted or inadequate also raises questions with regards to crew selection and criteria associated with such selection. Will astronauts have different social and personal traits that may deem them more advantageous to surviving the psychological challenges that long-duration and distant space missions will present to a crew? Will astronaut selection criteria be changed and/or modified to fit the personality type best suited for such necessary challenges and required mental/physical flexibility? What type of self-control characteristics would a selection committee look for in such individuals to complete these types of missions? Furthermore, how will post-mission recovery and the return to regular life be different for space explorers that embark on these long-duration and more distant space missions? How will their families cope while they are gone, and how will they adjust to the astronaut returning to their lives once again? Will the return to Earth and regular life be too difficult (physically, physiologically, and psychologically) for the astronaut? All these questions and more will arise and have to be answered as we move forward in exploring space further from Earth and for longer-durations. But the most exciting part of all of these questions is that as a civilization we are about to embark on the discovery of the answers in the very near future as we take larger space crews to the ISS for 6 months and longer and then start training our astronauts for missions back to the Moon.

CHAPTER V

FUTURE RESEARCH DIRECTIONS

In providing some other suggestions for future group dynamic research efforts, perhaps the implementation of the NASA Team Performance Model could be a useful tool for research carried in space analog environments such as the research stations in Antarctica and the Mars Desert Research Station (MDRS) analog sites located around the world, etc. This model was first devised and implemented for use with groups carrying out work and research in isolated and confined environments here on Earth. The model involves three primary variables (Input, Process, and Output) in an effort to better understand the complex factors associated with how groups develop cohesiveness when living and working in isolated and confined extreme environments. Figure 16 shows a flow diagram of the Team Performance Model. In understanding the model, the process variables are those which show the mechanism by which the input variables affect the output variables. Input variables would include things such as individual traits (personality, knowledge, and skill level); group traits (team structures, leadership style, and group incentives); organizational aspects (support, goals, rewards); and environmental aspects (tasks and stressors). Output variables on the other hand can be measured in two ways: mission performance (including safety, efficiency, and effectiveness); and personal/group performance (including satisfaction and group cohesion). Interpreting the process variables would include a consideration of factors such as: group dynamics; how individuals with different traits interact, communicate, and solve problems together; decision making; task management; leadership; and workload distribution.

Input Variables -----> Process Variables -----> Output Variables

Figure 16. Flow diagram of the NASA Team Performance Model. (University of North Dakota Space Studies Department, 2006).

Using such a model in future Earth-based space analog environments could provide a deeper understanding of the 'team performance' aspect of groups living and working in isolated and confined extreme (ICE) environments. Combining this model with the methodologies developed and studied by Bishop et al. (2006a, 2006b) and Allner et al. (2008a, 2008b, 2008c) with MDRS crews could be a useful consideration for various aspects associated with selecting and training future space crews for long-duration space missions.

On another note the analysis of past expeditions as a means by which to provide suggestions and/or ideas as to how space missions should be organized and carried out in the future is something that has been considered and utilized for quite some time now. However, with regards to more distant past exploration consideration (more than 100 years ago), this has not been the case. Allner and Rygalov (2008) have suggested the value of an analysis of the Lewis and Clark Expedition of 1803-06, which was considered to be a highly successful long-duration mission. But what about analyzing similar expeditions of the distant past that weren't as successful? Suggested expeditions for such consideration could be the Burke and Wills Australian Expedition of 1860 (Zielinski, 2008), Franklin's Expedition of 1845, or the more distant Magellan Round the Globe Expedition (1519-1522) (Ferdinand Magellan, 1997) which was analyzed extensively by Allner and Rygalov (2006). An analysis of past expeditions that were not only successful, but also those that failed, is essential when implementing the 'lessons learned' for future space mission consideration. Similar study comparisons have been done more recently by researchers such as Stuster (1996) in his book *Bold Endeavors*, which encompassed such a 'lessons learned' overview of the last 100 years of Antarctic expeditions. Likewise, if we are going to consider the successes of more distant past expeditions, we might also want to consider those that failed and learn what we can from them as well.

In considering the successes and failures of such past expeditions a further consideration would be to analyze the diary accounts for indications as to the psychological aspects associated with such successes and failures. The challenge here would be that the analysis of such information would be highly subjective and interpretive in several respects (from the point of view of the explorers who wrote the diary accounts---suppression of true feelings/emotions because of the implications associated with future publication of the diary materials---as well as the interpretive mindset of those conducting the analysis of the diary materials themselves). What 'lens' we should, and will, use to discover the 'lessons learned' will be the question? However, it is interesting to combine the field of psychology to some of these very past expeditions to look for clues as to how crews perceived stress and coped with it, how they developed group cohesiveness (or how they didn't), and how the leadership dynamic (tendencies) functioned and evolved over time, etc. As an example, after Allner and Rygalov (2008) extensively analyzed the Lewis and Clark Expedition, they then compared the research findings of this highly successful expedition to those of the Magellan Expedition, which had a very opposite outcome as it failed miserably (Allner & Rygalov, 2006). In this analysis they pointed out several early accounts that led to the mission being in jeopardy (Allner & Rygalov, 2006), while also comparing the two expeditions from the psychological viewpoint of motivational factors and Abraham Maslow's hierarchy of needs (Baron, 1995). Today astronauts selected to train for space missions have several qualities that make them suitable to live and work in such a high-risk environment. Among these qualities Brcic and Suedfeld (2008) found astronauts to have placed high value on achievement and hedonism (humor, enjoying life). Basically, they can be defined as individuals having a healthy personality and who are able to balance the many stresses of life (family, professional, personal, etc.). In many cases they would be categorized as having self-actualizing personalities. Maslow, in his search to discover the "nature of the healthy personality", found that only a very small percentage of the human population exhibited such a personality (Allner & Rygalov, 2006). Interestingly, one of the individuals he found to have such a self-actualizing and healthy personality was Thomas Jefferson, the U.S. President responsible for organizing and implementing the Lewis and Clark Expedition. In his analysis of Jefferson he concluded, "individuals who are self-actualizing persons are people who have exceptionally healthy personalities, marked by continued personal growth" (Weiten, 2001, p. 506). Perhaps utilizing the NASA Team Performance Model while also revisiting Maslow's findings and cross-analyzing this with a wide variety of recent and more distant past expeditions, might provide some useful clues as to how we might best proceed in our efforts to return to the Moon and establish a permanent presence, and then continue our human exploration efforts on to Mars and beyond.

APPENDICES

Appendix A
Acronyms

The following acronyms listed below are listed in the order they appear in the text of the paper:

NASA	National Aeronautics and Space Adminstration
ICE	Isolated and Confined Extreme
SMSP	Shuttle-Mir Space Program
POW	Prisoner of War
NEEMO	NASA Extreme Environment Mission Operations
L & C	Lewis and Clark
U.S.	United States
ISRU	In-Situ Resource Utilization
MDRS	Mars Desert Research Station
MSC	Mars Society Canada
ESMD	Exploration Systems Mission Directorate
Hab	Habitat
SFPQ	Six Factor Personality Questionnaire
GES	Group Environment Survey
EVA	Extra Vehicular Activity
ISS	International Space Station

Appedix B
Consent Form

SUBJECT CONSENT FORM

You are being asked to participate as a subject in the research project entitled, Assessing Group Dynamics In a Mars Simulation, under the direction of Sheryl L. Bishop, Ph.D.

Your participation in this study is completely voluntary and you have been told that you may refuse to participate or, if you volunteer to participate, you may stop your participation in this project at any time without prejudice and without jeopardizing your participation in the Mars Simulation Mission.

PURPOSE OF THE STUDY

The purpose of this study is to explore individual and group factors that contribute to successful team performance in extreme environments. You are being asked to participate because you have been selected to be a team member of the MDRS 2006 field season.

PROCEDURES

All participants will be administered the Astro-PCI, a battery of psychological questionnaires that assess various dimensions of personality prior to arrival at the habitat. Once there, participants will be asked three times (Day 1, mid mission and end mission) to complete an online questionnaire that measures 1) Personal and Group Functioning (a range of items designed to measure various factors of group identity, decision making and goal formation); 2) A brief (10 item) self-report measure of stress (Sheldon's Perceived Stress); and 3) Coping (assessed using a 28 item Brief Coping Questionnaire which measures 14 subscales related to coping strategies). A separate computer tool to be downloaded and installed on each of your laptops will measure neurocognitive functioning at the same specified time as the other measures. All of these measures will take about an hour to complete and should be done at the same period. A schedule will be provided to plan these into your rotation calendar.

NUMBER OF SUBJECTS PARTICIPATING AND DURATION OF YOUR PARTICIPATION

The anticipated number of subjects involved in the study will be 6-50. The study period will be the period covered by your particular mission starting on arrival at MDRS and continuing until departure (typically 2 weeks).

RISKS OF PARTICIPATION

The potential risks from participation in the study are minimal to none. All data from the questionnaires are coded to maintain confidentiality. Although some demographic information could possibly identify specific participants, only the Principal Researcher will have access to individual responses and no such identifying data will be reported in association with any particular response set. Due to the public nature of MDRS (e.g., webcam, Mars Society website), complete anonymity cannot be accomplished. However, all data will be coded so that specific individual responses will be unlinked with identity relevant information.

BENEFITS TO THE SUBJECT

There are no direct benefits to you from participation in this study.

BENEFITS TO SOCIETY

Investigations into factors that contribute to successful real world teams are typically limited to small groups in which myriad factors contribute to the outcome. The opportunity to investigate some of these factors in a simulated, controlled situation will hopefully lead to greater insight into key factors that will contribute to improved selection, training and support of teams in the future.

REIMBURSEMENT FOR EXPENSES

There is no reimbursement for lost time, travel, parking, meals, etc. for your participation in this study. All expenses for the Mission are covered by the individual or the Mars Society per the stipulations in the separate contract with that organization.

COMPENSATION FOR RESEARCH RELATED INJURY

Since the data collection is primarily completion of questionnaires, there is no anticipation for injury. There are no plans to provide any forms of compensation should any injury occur. However, you are not waiving any of your legal rights by participating in this study.

COSTS OF PARTICIPATION

All study-related costs associated with your participation (e.g., questionnaires) will be paid by the Principal Investigator, Sheryl L. Bishop or designated sponsors. There are no costs to the participant.

USE AND DISCLOSURE OF YOUR HEALTH INFORMATION

All of the personality and group functioning assessments are being done only because you are in this study. The study results will be given to you and will not be included in your medical record. Your records may be reviewed in order to meet federal or state regulations. Reviewers may include, for example, representatives of the Food and Drug Administration and UTMB. This authorization continues until the end of the research study.

ADDITIONAL REQUIRED CLAUSES

1. Informed consent is required of all persons in this project. Whether or not you provide a signed informed consent for this research study will have no effect on your current or future relationship with UTMB.

2. The principal and alternate procedures, including the experimental procedures in this project, have been identified and explained to you in language that you understood.

3. The risks and discomforts from the procedures have been explained to you.

4. The expected benefits from the procedures have been explained to you.

5. An offer has been made to answer any questions that you may have about these procedures. If you have any questions before, during or after the study, or if you need to report a research related injury, you may contact Dr. Sheryl Bishop at 409-747-6027 or, if after normal office hours, at 281-788-5844.

6. Your participation in this study is completely voluntary and you have been told that you may refuse to participate or stop your participation in this project at any time without penalty or loss of benefits and without jeopardizing your medical care at UTMB. If you decide to stop your participation in this project and revoke your authorization for the use and disclosure of your health information, UTMB may continue to use and disclose your health information in some instances. This would include any health information that was used or disclosed prior to your decision to stop participation and needed in order to maintain the integrity of the research study. If we get any information that might change your mind about participating, we will give you the information and allow you to reconsider whether or not to continue.

7. If you are injured or have an adverse reaction (bad side effect), because of this research, you should immediately contact one of the personnel listed in Clause #5 above. Emergency medical treatment will be available at The University of Texas Medical Branch hospitals at no cost to you. No additional compensation will be provided. Agreeing to this does not mean that you are giving up any legal rights that you may have.

8. If you have any questions regarding your rights as a subject participating in this study, you may contact Dr. Wayne R. Patterson, Senior Assistant Vice President for Research, Institutional Review Board, at (409) 266-9475.

9. You have a right to privacy, and all information that is obtained in connection with this study and that can be identified with you will remain confidential as far as possible within state and federal law. However, information gained from this study that can be identified with you may be released to no one other than the investigators, your personal physician, and the UTMB Institutional Review Board. The results of this study may be published in scientific journals without identifying you by name.

The purpose of this study, procedures to be followed, risks and benefits have been explained to you. You have been allowed to ask questions and your questions have been answered to your satisfaction. You have been told who to contact if you have additional questions. You have read this consent form and voluntarily agree to participate as a subject in this study. You are free to withdraw your consent, including your authorization for the use and disclosure of your health information, at any time. You may withdraw your consent by notifying Dr. Bishop at 409-747-6029. You should keep a copy of the consent form you have signed.

Date — PRINTED NAME of Subject

Date — Signature of Subject

Date — Signature of Authorized Representative *(if applicable)*

Date — Signature of Witness

Description of Authorized Representative's Authority to Act for Subject *(if applicable)*

Using language that is understandable and appropriate, I have discussed this project and the items listed above with the subject and/or his/her authorized representatives.

Date — Signature of Person Obtaining Consent

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